Candidate Name: ______________________

Class	Adm No

H

millennia institute

2019Preliminary Exams

Pre-University 3

H2 PHYSICS **9749/01**

Paper 1 Multiple choices **23 September**

1 hour

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glueor correction fluid.

Write your name, class,admin number on the Multiple ChoiceAnswer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.
The use of approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	c	=	$3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	μ_0	=	$4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	ε_0	=	$8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
			$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	e	=	$1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	h	=	$6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	u	=	$1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	m_e	=	$9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	m_p	=	$1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	R	=	$8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	N_A	=	$6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	k	=	$1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	G	=	$6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	g	=	$9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

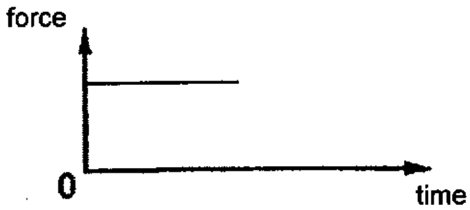
[Turn over

1 The human head consists of the skull, brain, eyes, teeth, and the facial muscles and skin.

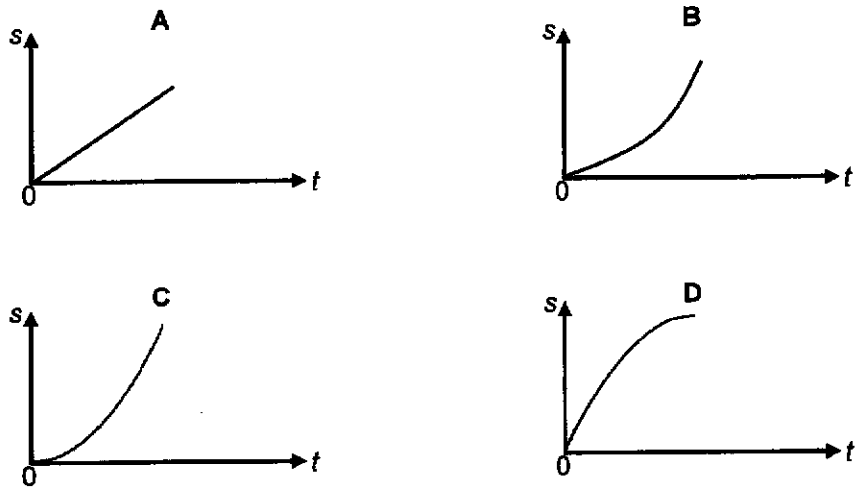
What is a good estimation of the weight of the head of a typical adult?

A 1.0 kg **B** 3.0 kg **C** 5.0 kg **D** 7.0 kg

2 A car driver steps down on the accelerator when thetraffic lights go green.The force on the car varies with time asshown, with time t = 0 as the moment when the traffic lights go green.



Which of the following graphs best represents how the displacements$s$of the car varies with time$t$?



3 A stone is thrown vertically upwards in a medium in whichthe viscous drag cannot be neglected. If the times of flightfor the upward motion t_u and the downward motiont_d (toreturn to the same level) are compared, which of the following statement is corrent?

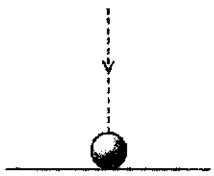
A $t_d < t_u$,because at a given speed the net acceleratingforce when the stone is moving downwards is greaterthan the retarding force when it is moving upwards.

B $t_d < t_u$,because the stone is moving with the greatest speed at the moment of projection and so greatest effect of the viscous drag.

C $t_d = t_u$, because viscous dragalways opposes motion and so will affect motion of the stone with the same effect whether the stone is moving upwards ordownwards.

D $t_d > t_u$,because at a given speed the net acceleratingforce when the body is moving downwards is smallerthan the retarding force when it is moving upwards.

4 A ball falls vertically on to a horizontal surface. The momentum of the ball just before it hits the surface is mv.



The ball collides inelastically with the surface and rebounds from it.

What is a possible value for the magnitude of the change in momentum of the ball from just before until just after contact with the surface?

A $0.25mv$

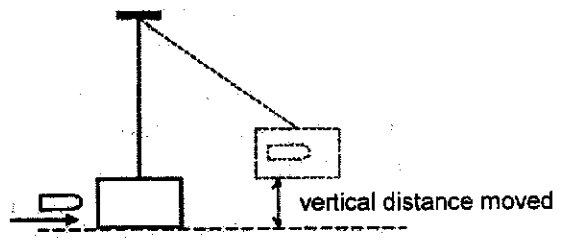
B $1.0mv$

C $1.25mv$

D $2.0mv$

5 A small plastic bullet of mass *m* is fired horizontally into a suspended block of wood of mass *M* and becomes embedded in the block, which rises up as shown in the diagram below.

Which of the following statements regarding the bullet and the wooden block is correct?



A The total mechanical energy of the bullet and block is conserved because they move with the same velocity after the collision.

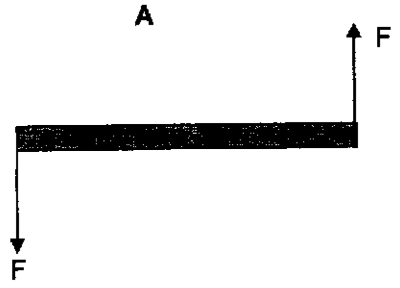
B The gravitational potential energy gained by the block is equal to the loss in kinetic energy by the bullet.

C There is heat produced in the collision because the collision is inelastic.

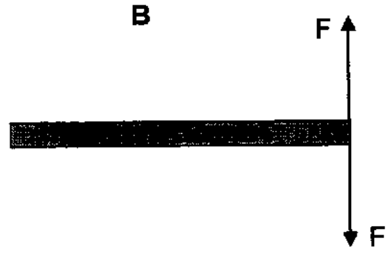
D The total horizontal momentum of the bullet and block is not conserved because there is a resultant horizontal force acting on them.

6 In which situation could the pair of forces applied to the rigid bar produce a couple?

A

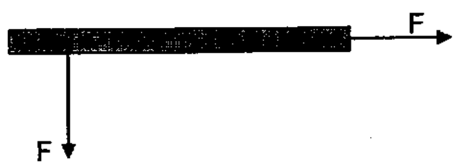


B



C

D



7 A balloon of mass 15.0 g is filled with helium to a volume of 4.50 m^3 and attached tothe ground via a light elastic cord of constant k = 80 N m^{-1}. The wind blows on the balloon such that the elastic cord makes an angle of 60° to the ground. Density of air is 1.29 kg m^{-3} and density of helium is 0.180 kg m^{-3}.

What is the extension of the elastic cord when the balloon is at equilibrium in the above position?

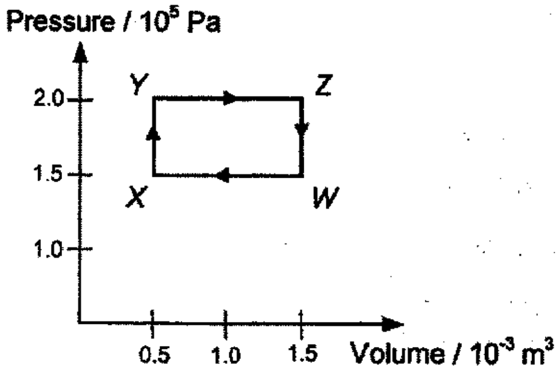
A 0.615 m

B 0.650 m

C 0.705 m

D 0.750 m

8 An ideal gas undergoes the cycle of pressureand volume changes $W \rightarrow X \rightarrow Y \rightarrow Z \rightarrow W$as shown in the diagram below.



What is the net work done on the gas?

A - 50 J

B 50 J

C - 150 J

D 150 J

[Turn over

9 A spring that has natural length of 20 cm takes 5.0 J of work to be stretched by 5.0 cm.

Given that the spring obeys Hooke's Law, what is the additional work required to stretch it a further 5.0 cm?

A 5 J

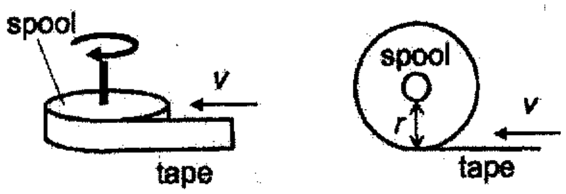
B 10 J

C 15 J

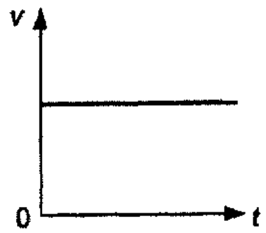
D 20 J

10 A straight length of tape winds onto a spool rotating about a fixed axis with constant angular velocity, such that the radius of the roll increases at asteady rate.

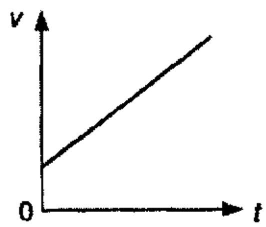
Which one of the following graphsbelow correctly shows how the speed v atwhich the tape moves towards the roll varieswith time$t$?



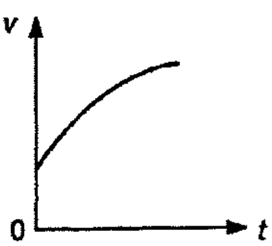
A



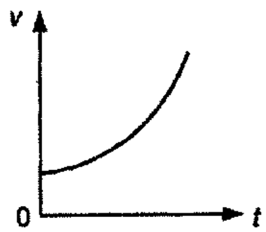
B



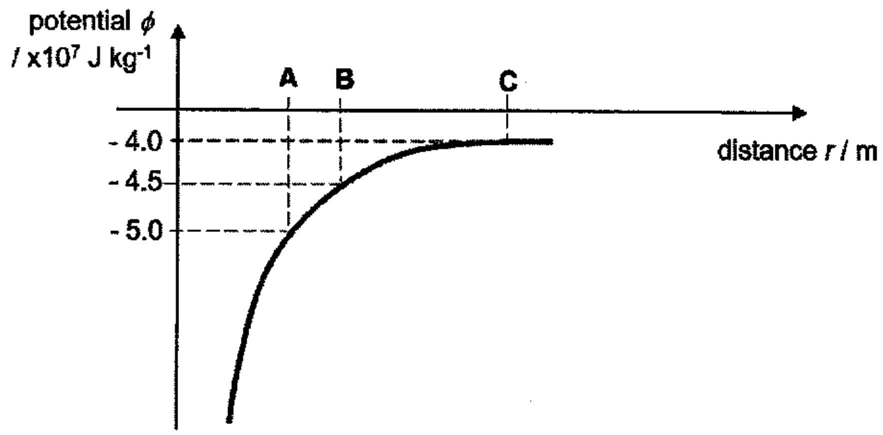
C



D



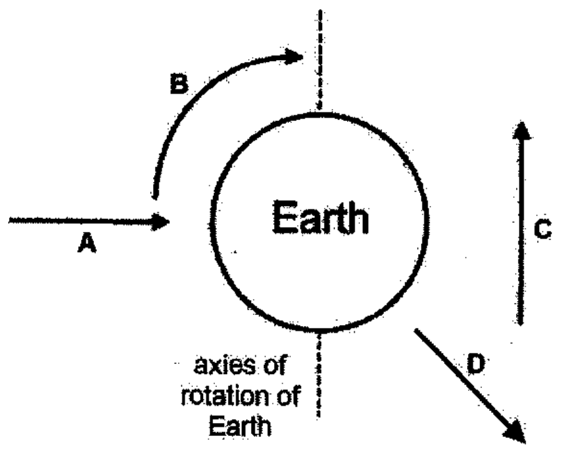
11 The graph (not to scale) below shows how the gravitational potential ϕ of Earth varies with distance r from its centre, with values of ϕ given for three positions A, B, and C. Mass of Earth is 6.0×10^{24} kg.



What are the distances **AB** and **BC**?

	distance **AB** / x 10^6m	distance **BC** / x 10^6m
A	0.89	1.1
B	0.89	1.8
C	8.9	11.1
D	8.9	17.8

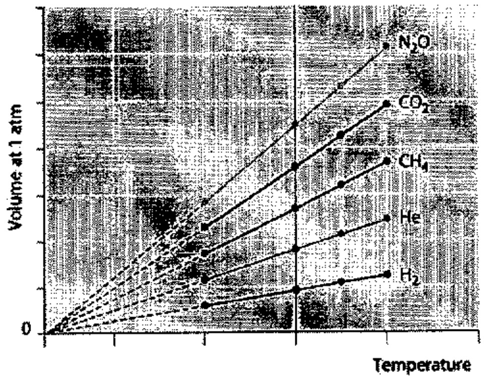
12 The diagram below shows four possible paths of a spacecraft moving near the Earth but well above any influence of the atmosphere.



Which path is **not** possible unless the spacecraft fires its rockets as it follows the path?

[Turn over

13 A student takes some measurements to plot graphs of volume versus temperature for different amounts of selected gases at 1 atm pressure, as shown in digram below. He observed that all the plots extrapolate to the same point $T_o$on the temperature-axis, regardless of the type or the amount of the gas.



Which of the following rows are correct regarding T_o?

	value of T_o	nature of T_o
A	- 273.16 °C	It is the temperature at which water exists in all of its three states.
B	- 273.15 °C	It is the temperature at which no more heat can be removed from a system.
C	0 °C	It is the melting point of ice.
D	273.16 K	It is the temperature at which the particles in a substance becomes motionless.

14 Which of the following statements concerningphase change and internal energy is ***false*** ?

A During boiling, all the heat suppliedcauses both the internal kinetic andpotential energies to increase.

B During melting, all the heat suppliedcauses the increase in internal potentialenergy only.

C The mean kinetic energy of the liquidmolecules at boiling point is about thesame as that of the molecules whichhave just vaporised.

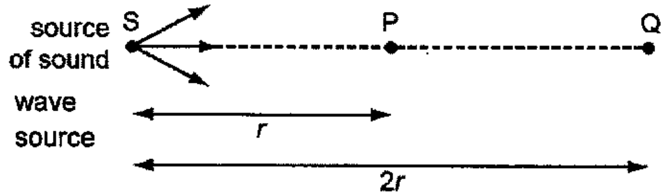
D The mean kinetic energy of the molecules just before and after melting isabout the same.

15 A verticalspring-mass system has a natural period of 1.25 s. A periodic force with frequency of 2.50 Hz is then applied to the system such that it oscillates with amplitude of 1.5 cm and reaches a steady state. The mass is observed to be at the bottom amplitude position at time t = 0.

What is the speed and direction of movement of the mass after 0.15 s?

	speed / $m s^{-1}$	direction of movement
A	0.111	downwards
B	0.167	downwards
C	0.111	upwards
D	0.167	upwards

16 The intensity I of a sound at a point P is inversely proportional to the square of the distance r of P from the source of the sound.



At point Q, distance $2r$ from source S, air molecules oscillate with amplitude 6.0 μm. Point P is at distance r from S.

What is the amplitude of oscillation of air molecules at P?

A 0.75 μm

B 1.5 μm

C 3.0μm

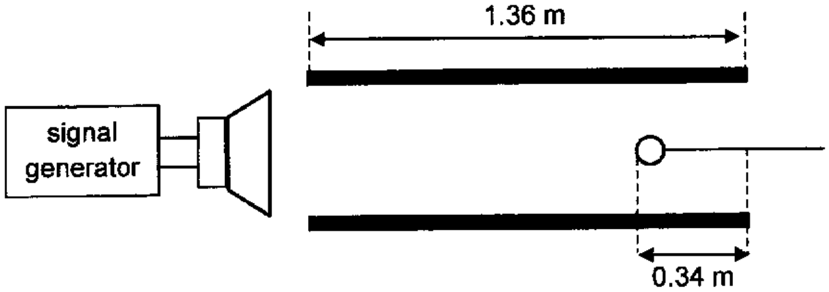
D 12.0μm

[Turn over

17 A speaker connected to a signal generator is placed infront of an open tube of length 1.36 m.

A small microphone is inserted inside the tube. It detects the first position with zero intensity at a distance of 0.34 m from the end. The microphone is then fixed in this position.

The speed of sound in the tube is 340 ms^{-1}.



The frequency of the signal generator is now increased until the microphone again detects zero intensity.

What is this new frequency?

A 750 Hz

B 1000 Hz

C 1500 Hz

D 3000 Hz

18 To be able to resolve a grain of green colour sand of radius 50 μm, the maximum distance that your eye can be positioned is 19 cm away from the grain.

What is the maximum distance for your eye to be able resolve a blue colour grain of sand?

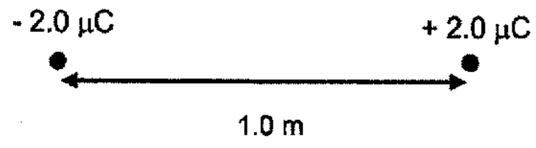
A The new distance is smaller than 19 cm.

B The distance remains the same.

C The new distance is larger than 19 cm.

D The blue grain of sand cannot be resolved.

19 A pair of equal and opposite charges each of2.0μC is separated by 1.0 m as shown below.



What is the magnitude of the electric field strength at themidpoint between the two charges?

A $0\ Vm^{-1}$

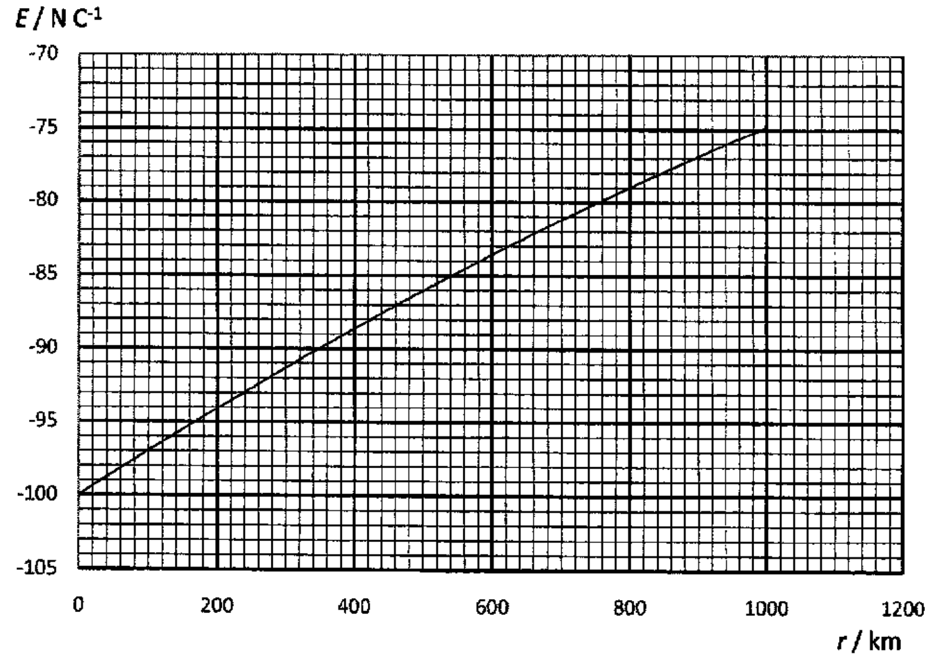
B $3.6\ x10^{4} Vm^{-1}$

C $7.2\ x10^{4} Vm^{-1}$

D $1.4\ x10^{5} Vm^{-1}$

20 The Earth can be assumed to be a sphere of radius 6400 km where charges are uniformly distributed on the surface. The figure below shows the variation of the electric field strength E with the distance r from the surface of the Earth.

The electric field strength E on the surface of the Earth is -100 N C^{-1}.



Which of the following is the electric potential of Earth at 500 km above its surface?

A -2.25×10^{-5} V

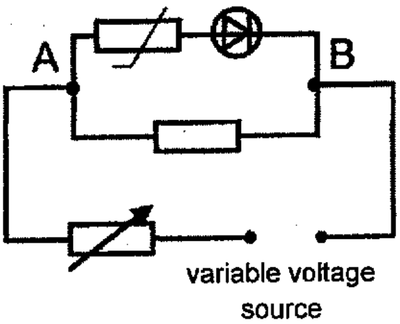
B -7.50×10^{-5} V

C the gradient of the tangent of graph at r = 500 km

D the area between the graph and r axis from infinity to r = 500 km

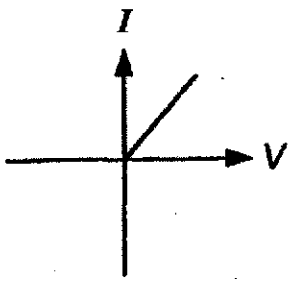
[Turn over

21 A circuit is set up as shown below.

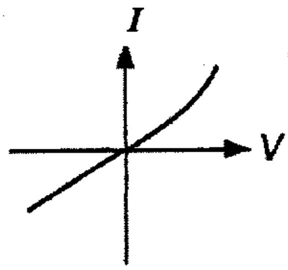


Which of the following I-V graphs represent thecurrent through, and voltage across, points AB?

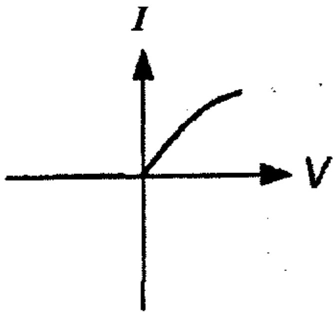
A



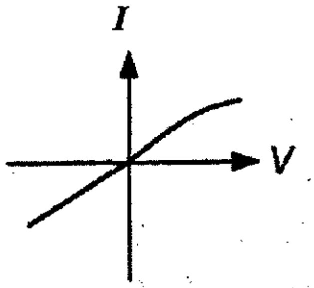
B



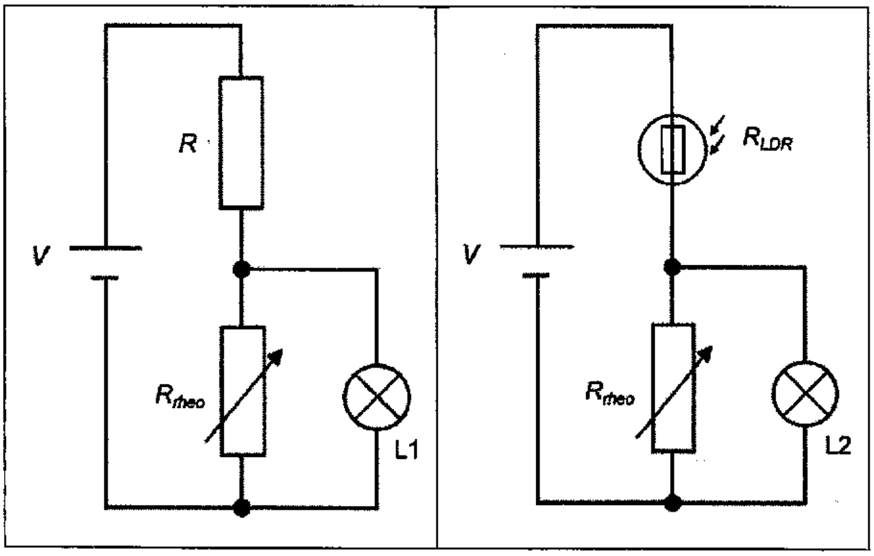
C



D



22 A fixed resistorand a light dependent resistor (LDR) are placed in two identical circuits far from each other. Initially when the circuit is connected, the resistance of the LDR R_{LDR}, the rheostat $R_{rheo}$and the fixed resistor R are equal. Assume the batteries have negligible internal resistance.

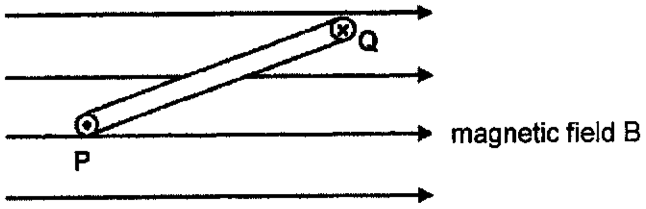


Which of the following correctly describes the brightness of L1 and L2 when varyingR_{rheo}in both circuits?

	R_{rheo} ***increases***	R_{rheo}***decreases***
A	L1 is brighter than L2	L1 is brighter than L2
B	L1 is brighter than L2	L2 is brighter than L1
C	L2 is brighter than L1	L1 is brighter than L2
D	L2 is brighter than L1	L2 is brighter than L1

[Turn over

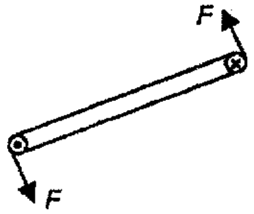
23 Diagram below shows a plan view of a current carrying rectangular coil in a uniform magnetic field B. The current in sideP is flowing perpendicularly out of the plane of the paper, the current in sideQ is flowing perpendicularly into the plane of the paper.



Which one of the following correctly shows thedirections of the forces that act on the sides ofthe coil?

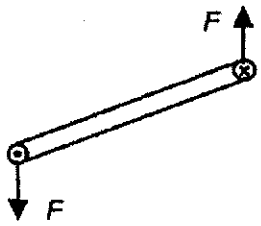
A

B



C

D



24 In a cross-field velocity selector apparatus, when the magnetic field B is applied at right angles to the electric field E, ions of charge q and speed v are selected to pass through.

In order to select ions of speed smaller than v, which of the following adjustments should bemade?

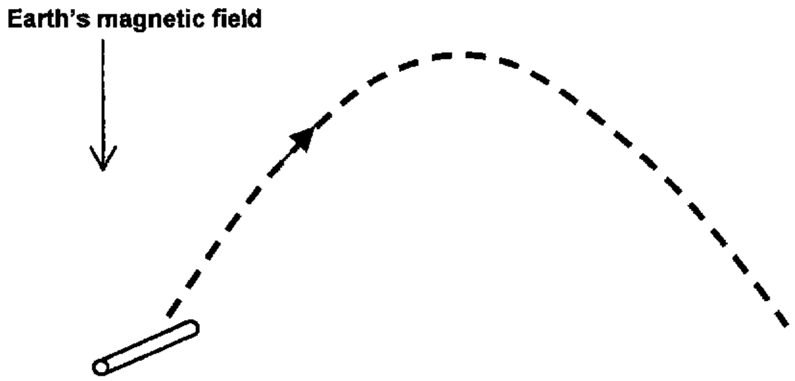
A increase q

B increase E

C increase B

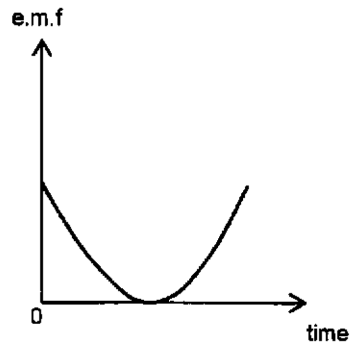
D decrease B

25 A metal rod is thrown such that it moves in a parabolic path. Along its movement, the metal rod's long axis remains perpendicular to the earth's magnetic field. It can be assumed that air resistance is negligible, the Earth's magnetic field is pointing downwards and is uniform throughout the rod's trajectory.

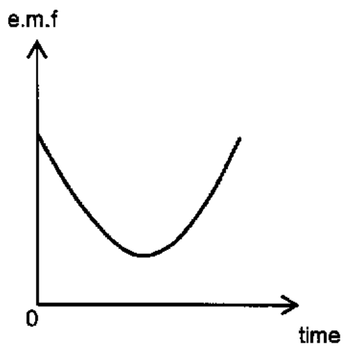


Which of the following graphs show the variation of the e.m.f. induced between both ends of the rod with time?

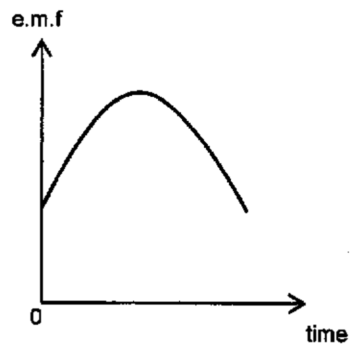
A



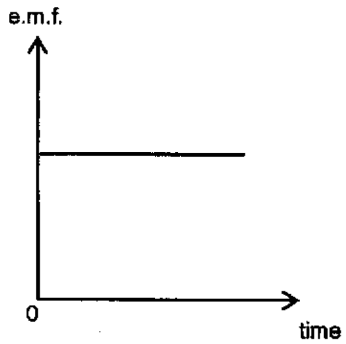
B



C



D



[Turn over

26 Thea.c.mains voltage supply $V$of a certain country is given by the expression

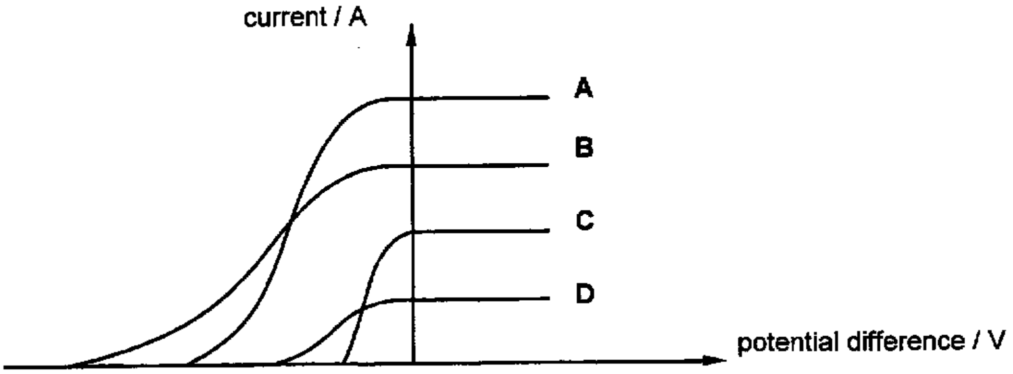
$$V = 141\ \sin(314t)\text{V}.$$

A device of resistance 200 Ω is connected to the mains.

What is the frequency of the a.c. mains, and theaverage power <P>delivered to the device?

	frequency / Hz	<P> / W
A	50	50
B	50	100
C	100	50
D	100	100

27 The figure below shows the currents observed in a photocell circuit as a function of the potential difference between the plates of the photocell when light beams A, B, C and D were each directed in turn at the cathode.



Which of the beams has the lowest wavelengths?

28 The uncertainty in the position of an electron is 43 nm. What is the minimum uncertainty in its velocity?

A 7.9 m s^{-1}

B 8.0 m s^{-1}

C 1.7×10^{3} m s^{-1}

D 1.7×10^{4} m s^{-1}

29 In the Rutherford scattering experiment, most α-particles passed through the foil undeflected.

Which one of the following is a correct conclusion from this result?

- **A** α-particles were helium nuclei.
- **B** The nucleus has a positive charge.
- **C** Most of the mass of an atom is within the nucleus.
- **D** The diameter of the nucleus is much less thanthe diameter of the atom.

30 A student claims that certain types of radiationcarry enough energy to break bonds between molecules and ionise atoms, and so causes "radiation sickness".

Which of the following statements with regard to the above claim is correct?

- **A** Radiation sickness can be caused bymicrowaves.
- **B** Ionising radiation can consist of gamma rays, alpha particles and beta particles.
- **C** Ionising radiation cannot consist of alpha particles and beta particles as these are not waves.
- **D** Radiation sickness can only be caused by human-made radiation and not by natural sources of radiation.

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Candidate Name: ______________________

Class	Adm No

H

millennia institute

2019Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/02**

Paper 2Structured Questions **17 September**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write your full name, class and Adm number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use		
1		/5
2		/10
3		/ 13
4		/10
5		/10
6		/10
7		/ 22
Presentation		
Total		/ 80

This document consists of **19**printed pages and **1** blank page.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Answer **all** the questions in the spaces provided.

1 The length of a piece of paper is measured as 280 ± 1 mm. Its width is measured as 230 ± 2 %. Area *A* is the area of one side of the piece of paper.

(a) State the value of *A* and its actual uncertainty to the appropriate number of significant figures.

A = ... ± .... mm^2 [3]

(b) The accepted value of *A* is $8.00 \times 10^4 mm^2$.
Use your answer in **(a)** to distinguish between *accuracy* and *precision*.

accuracy ....

....

....

precision ....

....

.... [2]

[Total: 5]

2 (a) (i) Explain what is meant by the term *work done*.

....

.... [1]

(ii) Hence derive the equation

$$E_p = mgh$$

for the potential energy change of a mass m moved through a vertical distance h near the Earth's surface.

[3]

(b) A typical escalator in a mall rises at an angle of 45°to the horizontal. It lifts people through a vertical height of 32 m in each minute. 60 people can fit on the escalator and there is a constant stream of people such that the escalator is always fully loaded. It can be assumed that all passengers remain standing still while on the escalator and the average mass of one passenger is 55 kg.

(i) Calculate the power needed to lift the passengers when the escalator is fully loaded.

power = ... W [2]

[Turn over

(ii) The total frictional force acting against motion of the escalator is 1.5×10^4 N when the escalator is fully loaded.

1. Calculate the power needed to overcome the friction.

power = ... W [2]

2. In lifting the passengers and overcoming friction, the motor is only 70% efficient due to other forms of energy loss. Calculate the power input for the motor driving the fully loaded escalator.

power = ... W [2]

[Total: 10]

3 (a) (i) With reference to the first law of thermodynamics, explain why there is considerable difference in magnitude between the specific latent heats of fusion and vaporisation for the same material.

....

....

....

....

.... [4]

(ii) Ethanol has a melting point of -120 °C and a boiling point of 78 °C.The specific latent heat of fusion is 110 J g^{-1} and specific latent heat of vaporisation is 840 J g^{-1}. The density and specific heat capacity of liquid ethanol are 0.79 g cm^{-3} and 2.4 J g^{-1} K^{-1}respectively.

Calculate the minimum thermal energy required to fully vapourise 2.0 cm^3 of ethanol that is initially at 30 °C.

required thermal energy = ... J [4]

[Turn over

(b) Some gas, assumed to behave ideally, is contained within a cylinder which is surrounded by insulation to prevent loss of heat, as shown in Fig. 3.1.

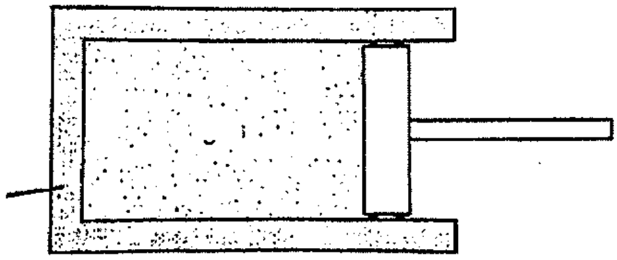

Fig. 3.1

Initially, the volume of gas is 2.9×10^{-5} m^3, its pressure is 2.6×10^{6} Pa and its temperature is 790 K.

(i) The gas expands to a volume of 2.9×10^{-4} m^3 and its temperature decreases to 314 K. Calculate the pressure of the gas after this expansion.

pressure of gas after expansion = ... Pa [2]

(ii) The work done by the gas during the expansion is 91 J. Determine the change in the internal energy of the gas during the expansion.

change in internal energy = ... J [1]

(iii) Explain the meaning of internal energy, and use your result in **(b)(ii)** to explain why a decrease in the temperature of the gas takes place during the expansion.

....

....

....

.... [2]

[Total: 13]

4 (a) Define*electric field strength* and state its SI unit.

....

....

.... [2]

(b) Two parallel pates are set a distance of 12 mm apart in a vacuum as shown in Fig. 4.1. The top plate is at a potential of +300 V and the bottom plate is at a potential of -300 V. A proton is placed in the vacuum and moved by the electric field from plateA to plate B.

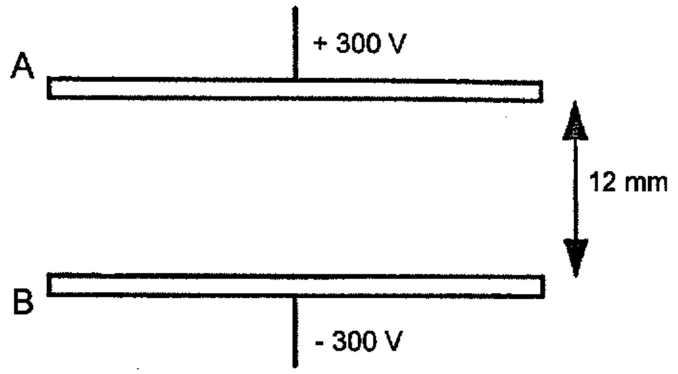

Fig. 4.1

(i) On Fig. 4.1, draw lines to show the electric field between the plates. [1]

(ii) Calculate the electric field strength between the parallel plates.

electric field strength = ... N C^{-1} [1]

(iii) Calculate the work done by the field on the proton.

work done = ... J [1]

[Turn over

(iv) State the gain in kinetic energy of the proton.

gain in kinetic energy = ... J [1]

(c) In a classical model of the hydrogen atom, the electron revolves around the positive nucleus, which is made up of single proton. Since the proton is very massive compared to the electron, the proton can be assumed stationary as the electron goes around it in a circular orbit. The radius of this circular orbit is taken to be 5.3×10^{-11} m, which is the radius of the hydrogen atom.

Estimate the average electric current along the electron's orbit.

electric current = ... A [4]

[Total: 10]

5 An alternating current varies with time in the way shown in Fig. 5.1.

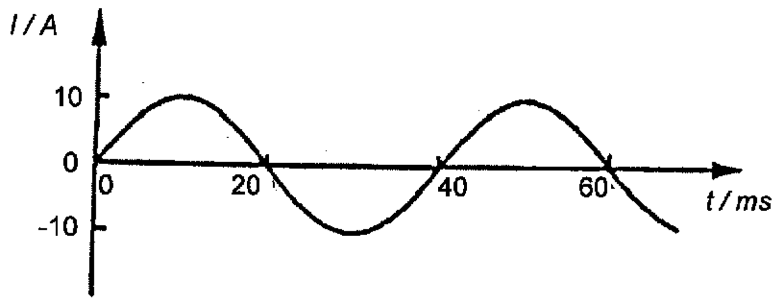

Fig. 5.1

(a) **(i)** By reference to heating effect, explain what is meant by the *root-mean-square* (r.m.s.) value of an alternating current.

....

....

.... [2]

(ii) Determine the frequency of the alternating current.

frequency = ... Hz [1]

(iii) Determine the peak value of the alternating current.

peak value of current = ... A [1]

(iv) Determine the root-mean-square value of the alternating current.

root-mean-square value of current = ... A [1]

(v) In the space below, sketch a graph to show how the power supplied by this alternating current to a resistor of resistance 5 Ω varies with time. Label values of peak power

[Turn over

and period on the Y-axis and X-axis respectively.

[2]

(b) **(i)** Explain what is meant by an *ideal transformer*.

....

.... [1]

(ii) The current shown in Fig. 5.1 is in the 300-turn primary coil of an ideal transformer. The secondary coil of the transformer has 6000 turns. Calculate the transformer's peak output current.

peak output current = ... A [2]

[Total: 10]

6 **(a)** In the space below draw a diagram of the setup used to demonstrate the photoelectric effect, and use it to explain how the photoelectric effect provides evidence for the particulate nature of electromagnetic radiation.

....

....

....

....

....

....

....

....

.... [4]

(b) State, with a reason, what modifications to the apparatus in the setup in(**a**) would be required, separately, to increase

(i) the energy of a photoelectron,

....

....

....

.... [1]

(ii) the rate of production of photoelectrons.

....

....

....

.... [2]

(c) Describe and explain an experiment that gave rise to a model for the wave nature of light.

[Turn over

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....

....

.... [3]

[Total: 10]

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[Turn over

7 The National Electrical Code (NEC), is an adoptable standard for the safe installation of electrical wiring and equipment in some countries. It is part of the National Fire Codes series published by the National Fire Protection Association (NFPA), a private trade association. Despite the use of the term "national", it is not a federal law. It is typically adopted by states and municipalities in an effort to standardize their enforcement of safe electrical practices. In some cases, the NEC is amended, altered and may even be rejected in lieu of regional regulations as voted on by local governing bodies. The "authority having jurisdiction" inspects for compliance with these minimum standards.

A type of wireused for interior wiring of houses, hotels, office buildings, and industrial plants, is referred to as wire "A". Wire "A"is permitted to carry no more than a specified maximum amount of current. The "wire gauge" is a standard method used to describe the diameter of wires.

Table 7.1 shows the diameter d and resistance R of a constant length L of the wire for various wire gauges. The constant length L for this set of data is 1.00 m.

Table. 7.1

Wire Gauge	d / mm	R / mΩ
14	0.27	19.0
12	0.32	13.9
10	0.38	9.70
8	0.46	6.60
6	0.56	4.40
5	0.91	1.68

$I_{max}$is the maximum amount of current that can flow in wire "A"of 1.00 m before it overheats. The graph of I_{max} against the diameter of the gauge d is plotted in Fig. 7.1 below.

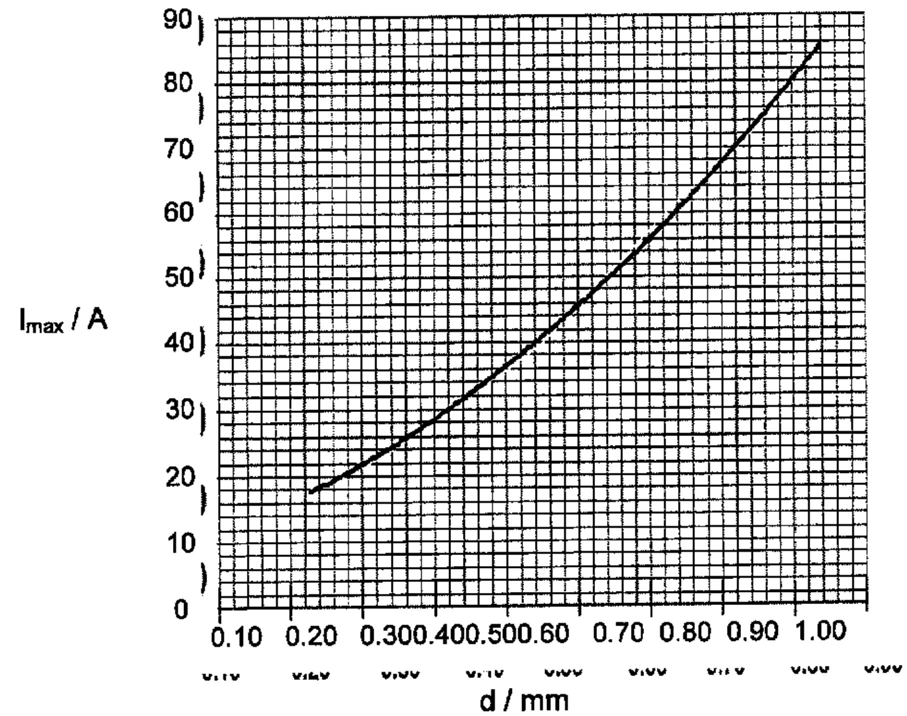

Fig. 7.1

A student, who is investigating how the resistance of wire "A" depends on the diameter of the wire, believes that resistance R of wire "A"is related to diameter d by the following equation:

$$R = kd^n$$

where k and n are constants.

The student uses Table. 7.1 to compute the data in Table 7.2 so that he can test his hypothesis.

Table. 7.2

ln (d / mm)	lg (R / mΩ)
-0.57	1.28
-0.49	1.14
-0.42	0.987
-0.33	0.820
-0.25	0.643
-0.041	0.225

The student then plots the variation of lg (d / mm) with lg (R / mΩ) on a graph. The graph is shown in Fig. 7.2.

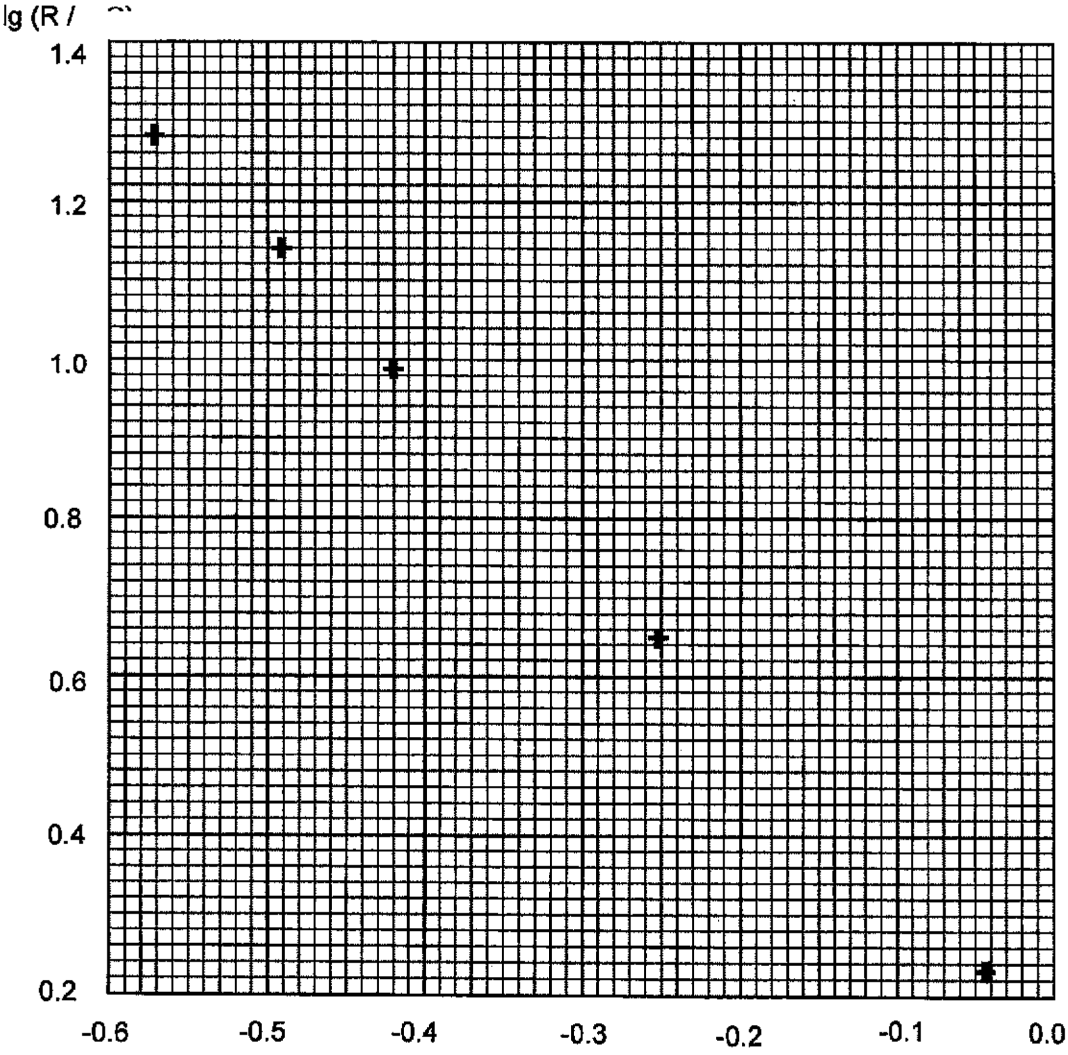

Fig. 7.2

[Tι ı over

(a) **(i)** Use Table 7.1 to suggest qualitatively the relationship between diameter d and resistance R.

....

....

.... [1]

(ii) Explain why the graph of Fig. 7.2 supports the student's hypothesis.

....

....

....

.... [2]

(b) **(i)** Plot the point for d = 0.46 mm on Fig. 7.2. [1]

(ii) Complete Fig. 7.2 by drawing the line of best fit. [1]

(iii) Determine the value of n from your line.

n = ... [2]

(c) Use Fig. 7.2 to find the resistance R of wire "A" with diameter 0.73 mm.

R = ... Ω [3]

(d) If k = 4ρL / π, determine the value of ρ, where L is the length of the wire. Include an appropriate unit forρ.

ρ = ... [4]

(e) A boiler, with resistance of 6.0 kΩ and rated at 5.4 MW is to be connected to two wire "A"s of length 1.00 m each as shown in Fig. 7.3 below.

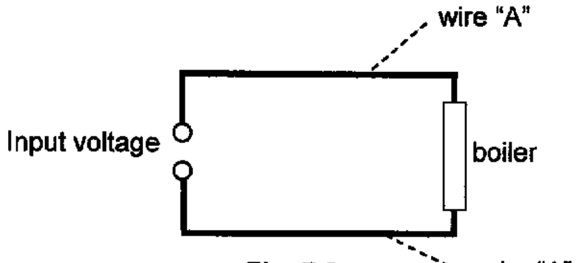

Fig. 7.3

(i) Determine the thinnest permissible wire that can be used with the boiler. Choose a suitable gauge from Table 7.1 and explain your choice.

....

.... [3]

[Turn over

(ii) Suggest a reason why a manufacturer would use the thinnest possible wire.

....

.... [1]

(iii) State and explain an advantage of using a thicker wire for this boiler.

....

....

.... [2]

(iv) Calculate the potential difference across each of the 1.00 m wiresfor the gauge selected in **(e)(i)**.

potential difference = ... V [2]

[Total: 22]

Class | Adm No

Candidate Name: ______________________

H

millennia institute

2019Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/03**

Paper 3 Long Structured Questions **19September**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.
Section B
Answer **one** questiononly.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use		
Sect A		
1		/10
2		/12
3		/10
4		/10
5		/10
6		/8
Sect B		
7		/20
8		/20
Presentation		
Total		/80

This question paper consists of **23** printed pages and **1** blank page.

[Turn over

Data

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	$(1/(36\pi)) \times 10^{-9}\ \mathrm{F\,m^{-1}}$
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pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
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magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** Fig. 1.1 shows the velocity-time graph of a small particle as it passes a point O.

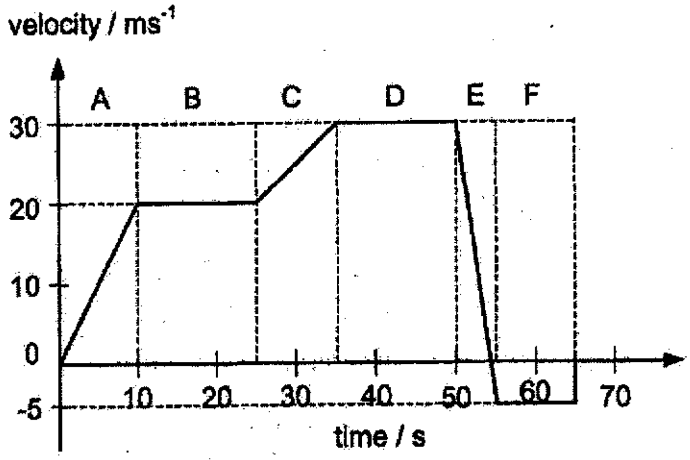

Fig. 1.1

(i) Describe qualitatively what happens in sections E and F of the journey.

....

....

....

.... [2]

(ii) Without doing any calculation, sketch the shape of the corresponding displacement-time graph in Fig. 1.2.

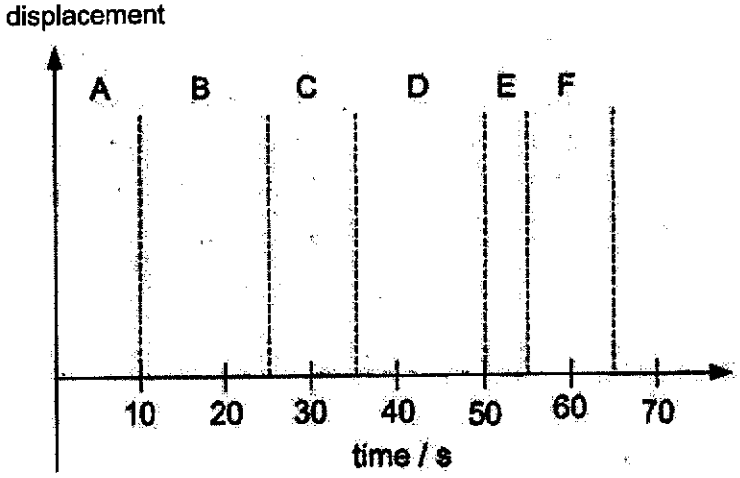

Fig. 1.2 [3]

(b) The small particle is placed at height h on a frictionless 30°ramp, as shown in

Fig. 1.3. When released at point **A**, the block slides down the ramp to point **B** and then falls 1 m to the floor. It lands in the small hole **C** which is located 1 m from the end of the ramp.

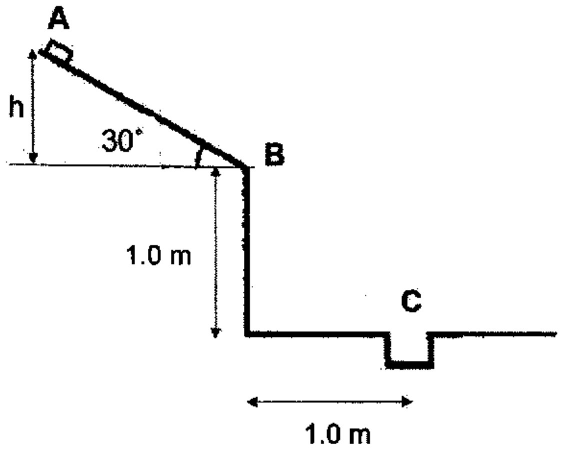

Fig. 1.3

(i) Show that the velocity at **B** is 3.9 m s^{-1}.

[3]

(ii) At what height h should the small particle be released in order to land in the hole **C**?

h = ... m [2]

[Total: 10]

[Turn over

2 Data for the Earth and the Moon are given below:

$$\frac{\text{Radius of Earth}}{\text{Radius of Moon}} = 3.7$$

$$\frac{\text{Mass of Earth}}{\text{Mass of Moon}} = 81$$

Separation of the Moon from Earth is 3.84×10^8 m and the gravitational field strength due to Earth at its surface is 9.8 N kg^{-1}.

(a) Calculate the gravitational field strength due to the Moon at its surface.

gravitational field strength = ... N kg^{-1} **[3]**

(b) There is a point on the line between the Earth and the Moon at which their combined gravitational field strength is zero.

Calculate the distance between this point and the centre of the Earth.

distance = ... m **[2]**

(c) The Moon orbits around the Earth with a period of 27.3 days.

(i) Calculate the angular speed of the Moon.

angular speed = ... rad s^{-1} [1]

(ii) Calculate the mass of the Earth.

mass = ... kg [2]

(iii) Determine the gravitational force between the Earth and the Moon.

gravitational force = ... N [2]

(iv) The force calculated in **(c)(iii)** is very large. Suggest why this force has negligible effect on the motion of the Earth.

....

....

[2]

[Total: 12]

[Turn over

3 (a) Explain the meaning of the following terms as applied to waves. You may include labelled diagrams as part of your explanation.

(i) polarisation

....

....

.... [2]

(ii) constructive interference

....

....

.... [2]

(b) Two polarising disks whose planes are parallel are centered on a common axis. The direction of the polarising axis in each case relative to the common vertical direction are as shown in Fig. 3.1. A plane polarised beam of light parallel to the vertical reference direction is incident from the left on the first disk with an intensity of I_i.

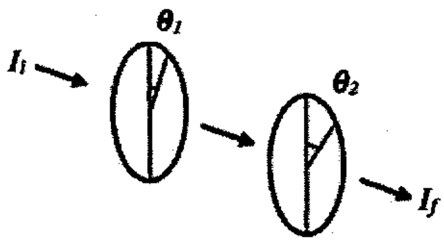

Fig. 3.1

Calculate the transmitted intensity I_f when $\theta_1 = 20.0°$ and $\theta_2 = 40.0°$. Leave your answer in terms of I_i.

I_f = ... [2]

(c) Point source P, consisting of light with wavelength 630 nm, passes through a narrow slit and is incident on a screen at a distance of 2.4 m from the slit. Fig. 3.2 below shows the variation of intensity I of the light on the screen with distance x along the screen.

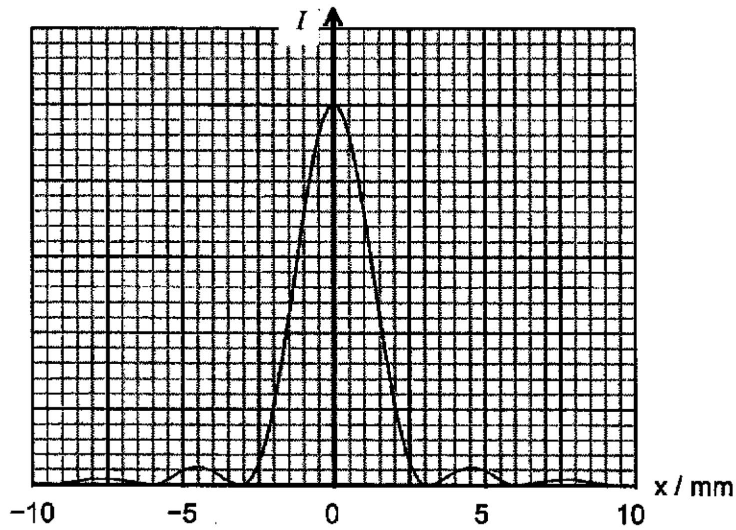

Fig. 3.2

(i) Use Fig. 3.2 to determine the width of the slit.

width = ... mm [2]

(ii) State the effect on the pattern on the screen if the width of the single slit is reduced.

....

....

.... [2]

[Total: 10]

[Turn over

4 (a) A wire has a diameter of 1.10 mm and is 98 m long.

The resistivity of copper is 1.1×10^{-6} Ω m.

(i) Calculate the resistance of this wire.

resistance = ... Ω [1]

(ii) When the wire hangs vertically, suspended from one end, it stretches slightly under its own weight.

State and explain what happens to the resistance of the wire.

....

....

.... [1]

(b) The wire in **(a)** is shortened and 1% of its total length is used to form wire PQ.

(i) Wire PQ is then connected to a cell of e.m.f. E_1 and internal resistance r in series with variable resistor R as shown in Fig. 4.1.

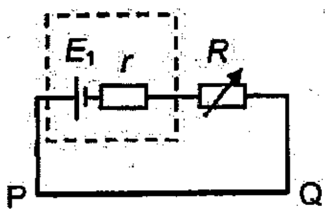

Fig. 4.1

Express the potential difference per unit length of PQ in terms of E_1, r and R.

[3]

(ii) Fig. 4.2 shows a potentiometer circuit that can be used to determine the internal resistance r of cell E_1. A standard cell of e.m.f. E_2 of negligible internal resistance is used in the branch circuit. E_1 and E_2 have e.m.f. of 12.0 V and 1.5 V respectively. When the resistance of the variable resistor is 1.0 Ω, the balanced length is obtained when the length of JQ is twice the length of PJ.

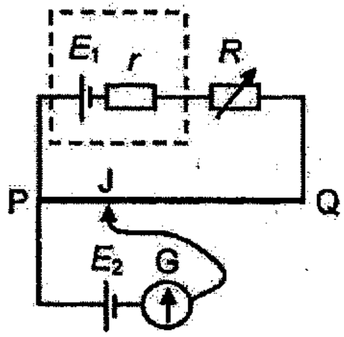

Fig. 4.2

1. Calculate the value of internal resistance, r.

r = ...Ω [3]

2. The resistance of the variable resistor R is now increased. Suggest why the resistance R cannot be higher than a particular value if the potentiometer in Fig. 4.2 is to be able to determine the value of internal resistance r.

....

....

....

.... [2]

[Total: 10]

[Turn over

5 A magnetic sail or magsail was proposed by Zubrin in 1991 to launch a spacecraft into space. A loop of cable is attached to the spacecraft, generating magnetic field. Fig. 5.1 shows a simplified diagram of a magsail, consisting of a circular loop of cable carrying a current I. The spacecraft is propelled by deflecting solar winds which consists of charged particles.

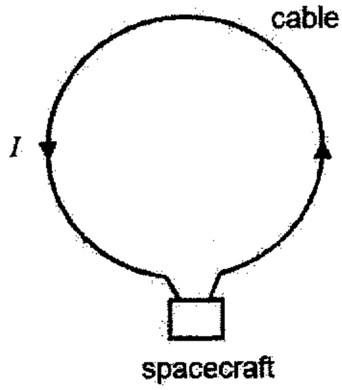

Fig. 5.1

(a) Explain how the magsail gets its propulsion from the deflection of the charged particles of solar winds.

....

....

.... [2]

(b) Suggest why the magsail cannot be propelled by photons.

....

.... [1]

(c) In Fig. 5.2, a magsail carrying a current I of 3.0 kA catches a solar wind consisting protons of kinetic energy 500 keV. The direction of the solar wind is along the plane of the page. The cable forms a circular shape with diameter 128 m.

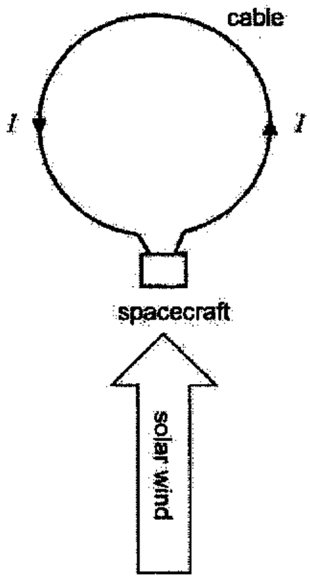

Fig. 5.2

(i) By considering only the magnetic field within the coil, draw the direction of the force experienced by the magsail and label it F in Fig 5.2. [1]

(ii) Calculate the speed of the protons.

speed of the protons = ... m s^{-1} [2]

(iii) Determine the magnetic flux density at the centre of the coil.

magnetic flux density = ... T [2]

(iv) Hence, calculate the force experienced by a proton passing through the centre of the coil.

force = ... N [2]

[Total: 10]

6 Fig. 6.1 shows a magnetic field of flux density 5.0×10^{-5} T passing through a

[Turn over

short-circuited coil of wire at an angle of 60° to the plane of the horizontal non-magnetic table on which the coil rests. The coil has 400 turns and an area of25 cm^2.

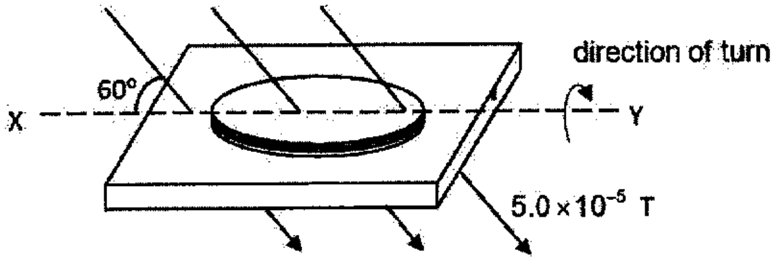

Fig. 6.1

(a) Calculate the magnetic flux linkage through the coil of wire at the above-mentioned position.

flux linkage = ... Wb-turns [2]

(b) After an initial push, the coil rotates by 180° about the axis XY in the direction shown in Fig. 6.1 in a duration of 2.5 s. Calculate

(i) the change in magnetic flux linkage of the coil,

change in flux linkage = ... Wb-turns [1]

(ii) the average e.m.f. induced.

e.m.f. = ... V [2]

(c) On Fig. 6.1, indicate the direction of the induced current in the coil immediately as it is being turned from the position shown. [1]

(d) Explain why the coil slows down and stops after it turns over by 180°. State the energy changes that take place.

....

....

.... [2]

[Total: 8]

Section B

Answer **one** question from this Section in the spaces provided.

7 **(a)** State the conditions for a body to remain in static equilibrium.

....

....

.... [2]

(b) A uniform rod of length L and weight 120 N is supported by two springs as shown in Fig. 7.1. A 400 N weight is suspended one quarter way from the left end.

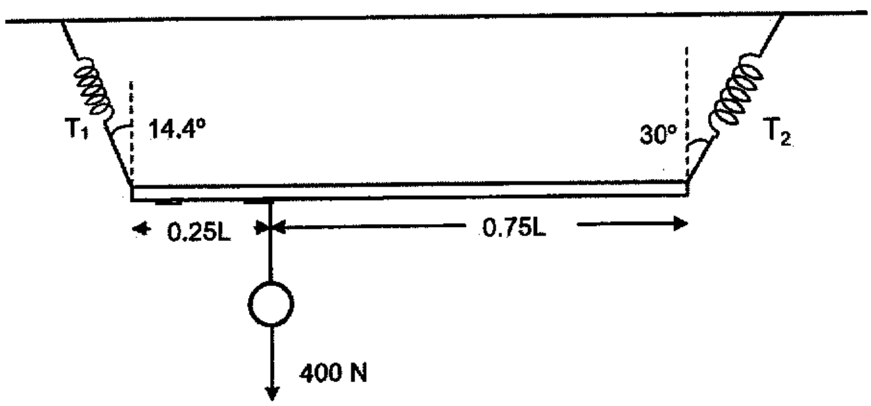

Fig. 7.1

Determine the tensions T_1 and T_2 that are exerted on the springs.

T_1 = ...N

T_2 = ...N [4]

(c) Distinguish between frequency and angular frequency for a body undergoing simple harmonic motion.

....

....

.... [2]

(d) A block of mass*m*which is 38 g is attached to two identical stretched springs, as shown in Fig. 7.2. Assume that no resistive forces act on the system.

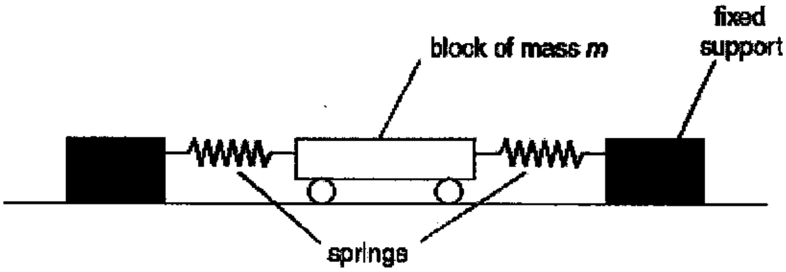

Fig. 7.2

(i) Both springs obey Hooke's Law and each has a spring constant *k*. The blockis displaced a horizontal distance *x* and released.

By considering Newton's Laws, show that the initial acceleration *a* of the mass *m* is given by

$$a = -\frac{2kx}{m}$$

[2]

(ii) The mass oscillates with simple harmonic motion of frequency 3.2 Hz and amplitude 2.8 cm.

Determine the total energy of the oscillation.

total energy = ... mJ [2]

[Turn over

(iii) At a particular instant, the kinetic energy of the mass is equal to the elastic potential energy of the springs. Calculate the distance from the equilibrium position at which this occurs.

distance = ...m **[3]**

(iv) On Fig. 7.3, use your answers in **(d)(II)** and **(d)(iii)** to sketch the variation with displacement *x* of

1. the total energy of the oscillation (label this graph T), [1]

2. the kinetic energy of the mass (label this graph K), [1]

3. the elastic potential energy of the springs (label this graph P). [1]

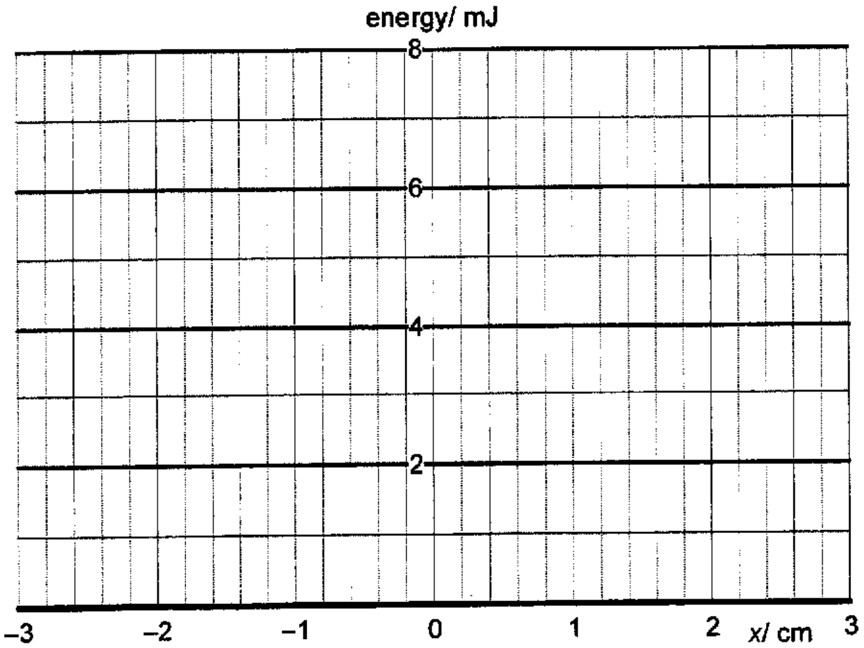

Fig. 7.3

(e) The system in Fig. 7.2 is now rearranged such that mass m oscillates vertically on only one of the springs, as shown in Fig. 7.4.

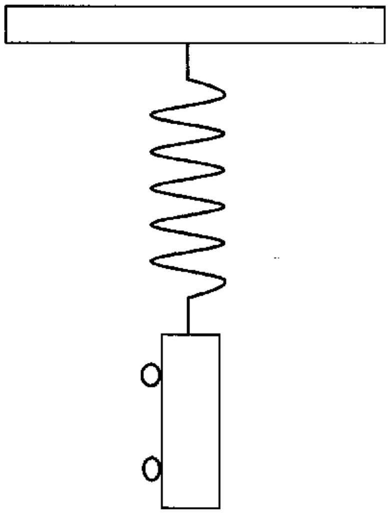

Fig. 7.4

By considering energy changes of the vertical spring-mass system, suggest and explain how the graphs in Fig. 7.3 would differ.

....

....

.... [2]

[Total: 20]

[Turn over

8 (a) State the principle of conservation of momentum.

....

....

.... [1]

(b) In a collision between a neutron and a uranium nucleus, the force that the neutron exerts on the uranium nucleus varies with time as shown in Fig. 8.1.

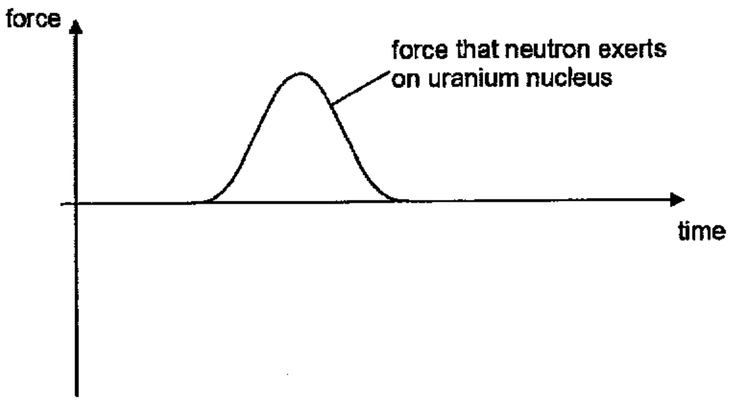

Fig. 8.1

(i) Sketch on Fig. 8.1, a graph of the force that the uranium nucleus exerts on the neutron. [1]

(ii) Explain how your answer to **(b)(i)** is consistent with **(a)**.

....

....

.... [2]

(c) In 1914, James Chadwick showed that the energies of the beta particles emitted for a radioactive source had a distribution of energies rather than with a distinct single value of energy.

Figure 8.2 shows the energy spectrum for beta particles emitted during the decay of Bismuth-210 ($^{210}_{83}Bi$). The intensity (vertical axis) indicates the number of beta particles emitted with each particular kinetic energy (horizontal axis).

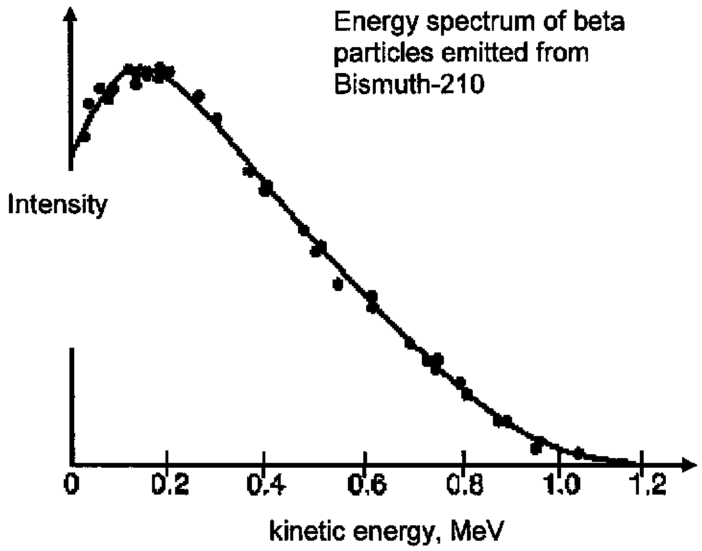

Fig. 8.2

(i) **1.** From Fig.8.2, determine Q, the maximum possible energy of the beta particle emitted.

Q = ... MeV [1]

2. Hence calculate the maximum speed of the beta particle.

maximum speed = ... m s^{-1} [1]

[Turn over

3. A Bismuth $^{210}_{83}Bi$ nuclide, decays into Polonium (chemical symbol: Po), emitting a beta particle with the maximum possible energy in the process.

Using your answer in **(c)(i)1.**, determine the mass of the resultant Polonium nucleus, in terms of *u*, and express your answer to 3 decimal places. (mass of a $^{210}_{83}Bi$ nucleus is 209.939 *u*; mass of proton m_p is 1.00729 *u*; mass of neutron m_n is 1.00867 *u*).

mass=........................ *u* [3]

(ii) From Fig. 8.2, identify the most probable energy for the beta particle.

most probable energy value = ... MeV [1]

(iii) The continuous spectrum of kinetic energy values of the emitted beta particles presented a problem to physicists up to 1930s. If a stationary nucleus decayed into a beta particle and a stable daughter nucleus only, it should lead to a distinct single value of energy for the emitted beta particle.

Explain, using conservation of linear momentum and energy, how the continuous spectrum of beta particle energies gave rise to this problem.

....

....

....

....

....

.... [2]

(iv) Suggest what was proposed by physicists to resolve the problem in **(c)(iii)**.

....

.... [1]

(d) Radioactive isotopes are often introduced into the body through the bloodstream. Their spread through the body can then be monitored by detecting the appearance of radiation in different organs. Iodine-131 (^{131}I), a beta emitter with a half-life of 8.04 days, is one such tracer. Suppose a scientist introduces a sample of ^{131}I with an activity of 375 Bq into the body and watches it spread to the organs.

(i) Define decay constant.

....

.... [1]

(ii) Assuming that all of the ^{131}I atoms in the sample went to the thyroid gland, calculate the decay rate in the thyroid 2.5 weeks later. Assume that none of the ^{131}I is eliminated by the body through physiological means.

decay rate = ... Bq [3]

(iii) Calculate the mass of ^{131}I required to produce an activity of 375 Bq.

mass = ... kg [3]

[Total: 20]

[Turn over

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Candidate Name: ____________________

Class	Adm. No.

H

millennia institute

2019Preliminary Exams
Pre-University 3

PHYSICS **9749/04**

Paper 4Practical **03September**

2 hour 30 mins

Candidates answer on the Question Paper.

Additional Materials: As listed on the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters,glue or correction fluid.

Answer **all** questions.

You will be allowed a maximum of one hour to work with the apparatus for Questions 1, and a maximum of one hour for Questions 2 and 3. You are advised to spend approximately 30 minutes on Question 4.

Write your answers in the spaces provided on the questionpaper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not useappropriate units.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
Q1	/ 21
Q2	/ 13
Q3	/ 9
Q4	/ 12
TOTAL	/ 55

This document consists of **16** printed pages.

[Turn over

1 In this experiment, you will investigate an electrical circuit that involves a wire attached to a metre rule.

(a) (i) Measure and record the diameter *d* of the wire.

d = ... [1]

(ii) Calculate the cross sectional area *A* of the wire.

A = ... [1]

(iii) Estimate the percentage uncertainty for the cross sectional area *A* of the wire.

percentage uncertainty of *A* = ... [2]

(b) (i) Assemble the circuit shown in Fig. 1.1. Resistor X is of value 10 Ω.

A, B and C are crocodile clips. Connect C to the screw on the wooden strip.

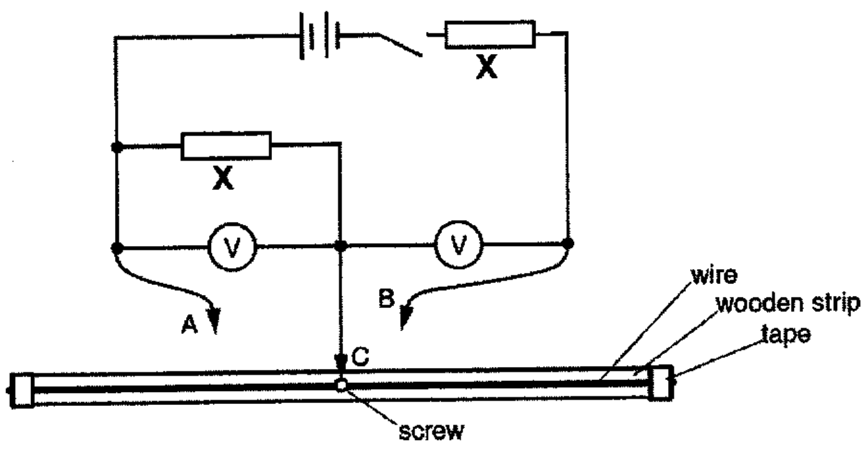

Fig. 1.1

(ii) Connect A to the wire at a distance *p* of approximately 20 cm from the screw, as shown in Fig. 1.2.

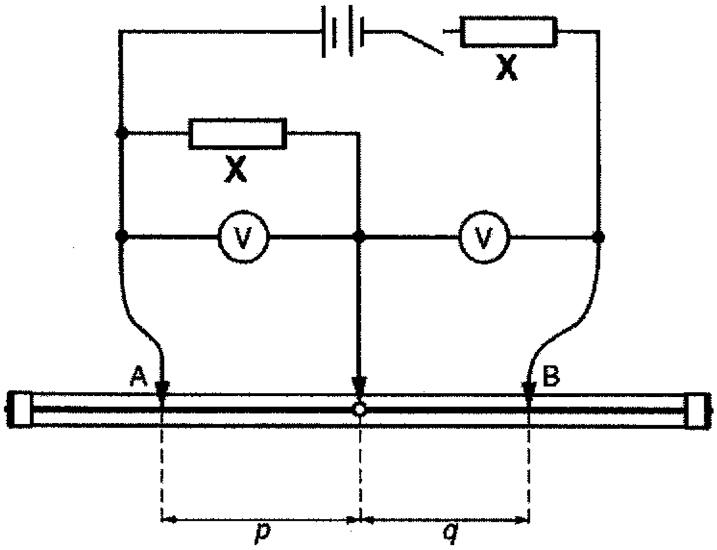

Fig. 1.2

(iii) Close the switch.

(iv) Connect B on the other side of the screw so that the two voltmeter readings **have the same value V**.

The distance between the screw and B is *q*, as shown in Fig. 1.2.Measure and record the voltmeter reading V and the distances *p* and *q*.

V = ...

p = ...

q = ...
[2]

(v) Open the switch.

[Turn over

(c) Vary p and repeat **(b)(ii)**to **(b)(v)**. Keep distance$p$ to be above 10 cm.

[5]

(d) $p$and q are related by the expression

$$p=aq + bpq$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

a = ...

b = ...
[6]

[Turn over

(e) Theory suggests that

$$\text{constant } b = \frac{\rho}{A\,\mathbf{X}}$$

where A is cross sectional area and ρ is resistivity of the constantan wire respectively.

The resistivity of constantan is known to be $4.9 \times 10^{-7}\,\Omega$m.

Determine whether the suggestion is possible. Justify your conclusion by referring to your value in **a(iii)**.

....

....

.... [2]

(f) **(i)** Suggest one significant source of error in this experiment.

....

....

....

.... [1]

(ii) Suggest an improvement that could be made to the experiment to address the error identified in **(f)(i)**. You may suggest the use of other apparatus or a different procedure.

....

....

.... [1]

[Total: 21]

2 In this experiment, you will investigate the motion of a mass and a spring.

(a) You are provided with a spring.

(i) Measure and record the diameter *d* of the coiled section of the spring as shown inFig. 2.1. Record the number *N* of turns in the coiled section.

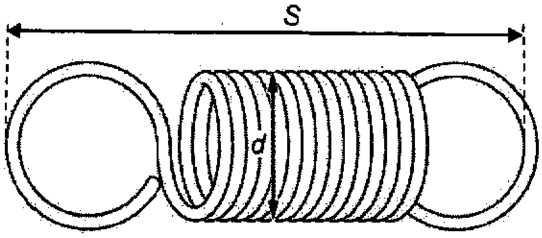

Fig. 2.1

d = ...

N= .... [2]

(ii) Calculate the length *L* of wire used to make the coiled section of the spring.

L = ...[1]

(iii) The length of the unstretched spring is *S*, as shown in Fig. 2.1.

Measure and record *S*.

S = ... [1]

[Turn over

(b) (i) Set up the apparatus as shown in Fig. 2.2 with the mass suspended from the springand secured with Blu-Tack.

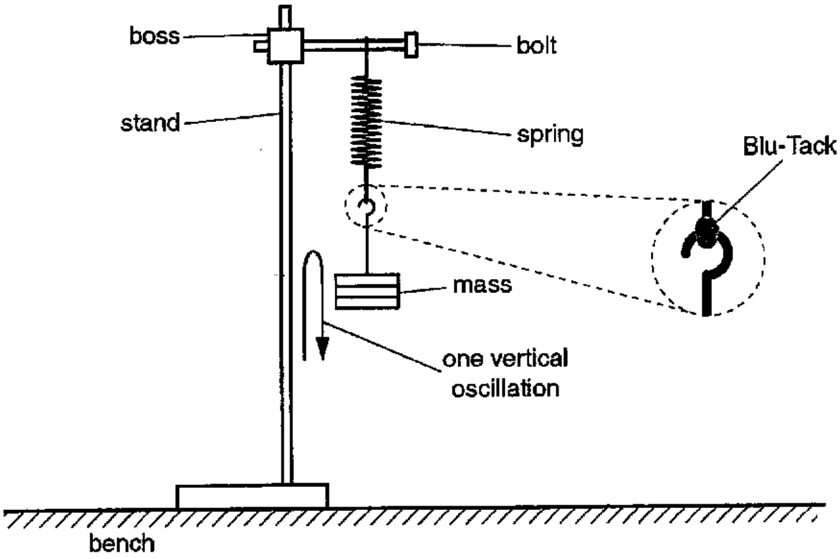

Fig. 2.2

(ii) Pull the mass down approximately 2 cm and release it.One vertical oscillation is shown in Fig. 2.2.

Measure and record the time *t* for themass to make 10 vertical oscillations.

t = ... [1]

(c) (i) Lower the bolt until the bottom of the stationary mass is approximately 6 cm abovethe bench, as shown in Fig. 2.3.

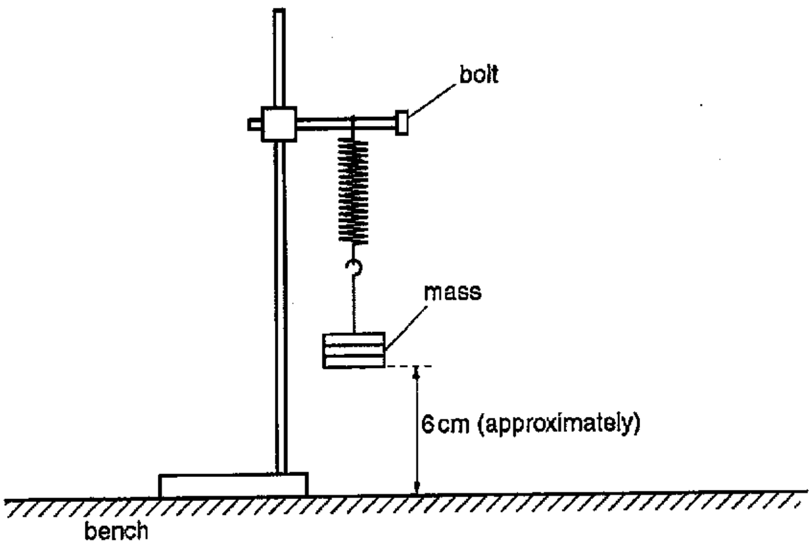

Fig. 2.3

(ii) Pull the mass down until it touches the bench.

Release the mass and watch the loop on the bolt, looking to see if the loop risesabove the bolt producing a gap at the top of the first oscillation as shown in
Fig. 2.4.

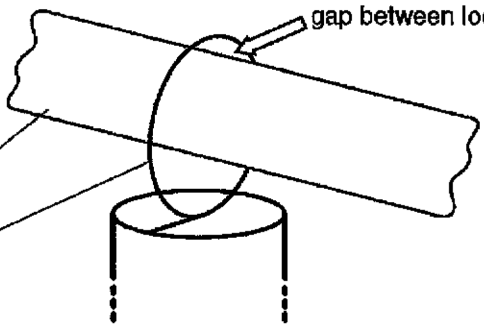

Fig. 2.4

(iii) Keep raising the bolt and repeating **(c)(ii)** until the loop just rises above the bolt at thetop of the first oscillation.

With the mass stationary, measure and record the distance D from the bottom ofthe mass to the bench.

D = ... [1]

(d) Estimate the percentage uncertainty in your value of D.

percentage uncertainty = ... [1]

(e) It is suggested that the relationship between D, t, and L is

$$D = kt^2L$$

where k is a constant.

Calculate k.

Give your value of k to an appropriate number of significant figures.

k = ... s^{-2} [1]

[Turn over

(f) The behavior of the oscillating system depends on the properties of the spring and mass. It is suggested that the time*t* is proportional to the number *n* of springs joined in a series, i.e. end–to-end configuration.

(i) Explain how you would investigate this relationship using the same apparatus.

Your account should include

- your experimental procedure
- control of variables
- how you would use your results to show proportionality
- why you might not have enough results to reach a valid conclusion.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [4]

(ii) Suggest a change to the spring that will improve your procedure in **(f)(i)**.

....

....

....

.... [1]

[Total: 13]

3 In this experiment, you will investigate how the rise of temperature of a vessel of water is related to the mass of boiling water added to it.

(a) On the inside ofa styrofoamcup about half-way up, there is a line drawn.

Make two further marks on the inside of this cup, equally spaced between the drawn line and a point near the top of the styrofoamcup.

(i) Collect some water at room temperature in the styrofoamcup up to the bottom line. Measure and record the temperature T_0 of this water.

T_0= .... [1]

(ii) Measure and record the mass M_0 of the styrofoamcup and the water.

M_0= .... [1]

(iii) Using the other styrofoamcup, collect some boiling water and pour this into the first styrofoamcup, until the water level reaches one of your drawn marks.

Measure and record the highest temperature T_1 of the water in the cup.

T_1= ....

(iv) Measure and record the total mass m_1 of the cup and its contents.

m_1= ....

(v) Calculate and record the rise in temperature R and the mass M of boiling water added to the cup.

R= ....

M= ....
[1]

[Turn over

(vi) Estimate the percentage uncertainties in your values of *R* and *M*.

percentage uncertainty of *R*= ....

percentage uncertainty of *M*= ....
[1]

(b) Pour away the water in the cup.

Repeat steps **a(i)**to **(a)(v)**to get another set of data for*R*and *M*.

R= ....

M= ....
[1]

(c) It is suggested that

$$\frac{1}{R}=\frac{X}{M}+Y$$

where X and Y are constants, and $\frac{X}{Y}$ is equal to the mass of water in (a)(ii).

(i) Use your values from a(i) to a(v) and (b) to calculate for value of $\frac{X}{Y}$.

Give your value of $\frac{X}{Y}$ to an appropriate number of significant figures. Include an appropriate unit.

$\frac{X}{Y}$= .... [2]

(ii) State whether the results of your experiment support the suggested relationship in **(c)**.

Justify your conclusion by referring to your values in **(a)(ii)** and **(a)(vi)**.

....

....

....

.... [1]

(iii) State and explain why it would be a better practice to use a graphical method using more data points to determine the value of $\frac{X}{Y}$.

....

....

....

.... [1]

[Total: 9]

[Turn over

4 When a light source is positioned behind a grating, bright spots can be observed if a screen is placed at a suitable position in front of the grating.

θ is the angle between the perpendicular line from middle of the grating to the middle bright spot on the screen and the line from middle of the grating to the third bright spot from the middle. The relationship between angle θ, number of lines per cm of the grating N, and frequency f of the light source, is

$$\sin\theta = 3\,k\,N^a f^b$$

where a, b and k are constants.

Design an experiment to determine the values of a and b.

You are provided with laser pointers of different frequencies, and also gratings of different N values.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

(a) the equipment you would use

(b) the procedure to be followed

(c) how you would produce a set of obvious bright spots

(d) the control of variables

(e) any precautions that should be taken to improve accuracy and safety of the experiment.

Diagram

....

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[Turn over

....[12]

[Total: 12]

Instructions for Lab

Question 1

Apparatus requirements (per set of apparatus unless otherwise specified)

Wooden strip of length 90.0 cm, with approximate cross-section 2 cm X 1 cm. See Note 1.

One woodscrew of approximate length 2 cm. See Note 1.

105 cm length of resistance wire. The wire should have a resistance of approximately 20 Ω m−1. Constantan 36 swg is used. See Note 1.

3 V d.c. power supply (e.g. two 1.5 V cells).

Switch.

Eleven connecting leads.

Three crocodile clips, suitable for connecting to leads. See Note 2.

Two voltmeters, each with a range of 0–20 V (tape over to show only 20 V range) and reading to 0.01 V. Multimeters set to this range are suitable provided the range switch is fixed and any unused terminals are covered.

One resistor with resistance 10 Ω with power rating 0.5 W (e.g. RS Components productcode 132-012). It should be fitted with terminals to enable connection to leads, and covered with label X. (X for 10 Ohms)

[illegible]

Metre rule with a millimetre scale.

Notes

1 Screw the woodscrew into the wooden strip half-way along its length. Wrap the middle of the resistance wire tightly around the woodscrew. Wrap the ends of the resistance wire over the ends of the wooden strip, and secure them with tape, as shown in Fig. 1.1.

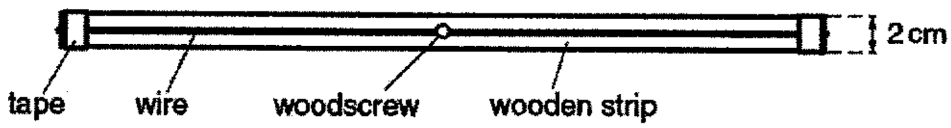


Fig. 1.1

2 Jaws of the crocodile clips should be cleaned so that they make good electrical contact with wire.

Information required by Examiners

Resistance per metre of the resistance wire. Sample set of numerical results.

Instructions for Lab

Question 2

Apparatus requirements (per set of apparatus unless otherwise specified)

Expendable spring with approximate outside diameter 15 mm, approximate coiled length 20 mm and approximate spring constant 25 N m^{-1} (e.g. Philip Harris product code B8G87194).

M10 bolt of length at least 8 cm.

Stopwatch reading to 0.1 s or better.

One Retort Stand.

Boss suitable for clamping the bolt horizontally to the stand.

1 g of Blu-Tack.

Mass hanger and masses with a total mass of 300 g. See Note 1.

Half-metre rule (or metre rule) with a millimetre scale.

Vernier Callipers

Notes

1 Slotted masses should be taped securely to the mass hanger.

2 The apparatus should be laid out on the bench. If it is to be used by another candidate, then it should be restored to its original state.

Information required by Examiners

Sample set of numerical results.

Instructions for Lab

Question 3

Apparatus requirements (per set of apparatus unless otherwise specified)

One styrofoam cup with a line drawn using a pen, at half-way up on inside of the cup

One styroforam cup

Hot water at 98 degree

Weighing balance

Cotton gloves

Alcohol in Glass Thermometer, read to 1 degree

Information required by Examiners

Sample set of numerical results.

2019Preliminary Exams

Pre-University 3

H2 PHYSICS **9749/01**

Paper 1 Multiple choices

ANSWERS

1	C	11	A	21	B
2	C	12	C	22	C9
3	D	13	B	23	A
4	C	14	A	24	C
5	C	15	D	25	D
6	A	16	D	26	A
7	C	17	A	27	B
8	A	18	C	28	D
9	C	19	D	29	D
10	B	20	D	30	B

1 **ANS: C**

Typical weight of an adult's head is 4.5 to 5.0 kg

Model the head as a sphere of radius ~ 10 cm
Comparing weight of this Volume x denisity of water = 4.1 kg,
density of head must be bigger than density of water =>closest and slightly higher estimate is 5 kg

2 **ANS: C**

Graph of $s = ut + ½ at^2$ with constant a

With zero gradient at t = 0

3 **ANS: D**

With use of a FBD, to see that
on the way up, Net retarding force = mg + Drag

on the way down, Net accelerating force = mg - Drag

so takes long time to move down back to same vertically level

4 **ANS: C**

Initial momentum = 1 mv downwards

If elastic , change in p = 2 mv upwards

If Inelastic, change in p must be more than 1 mv, but less than 2 mv.

Only C = 1.25mv is a possible answer

5 C This is a completely inelastic collision. Hence, total mechanical energy is not conserved.
A is wrong.

Gravitational potential energy gained by both block and bullet is equal to the loss in kinetic energy by the bullet.
B is wrong.

The total horizontal momentum of the two masses is conserved because the resultant horizontal force acting on them is zero.
D is wrong.

6 **Answer: A**

The 2 forces that form a Couple must have same magnitude, in opposite directions , and not acting through the same point.

7 **Answer: C**

Since the balloon is in equilibrium,

upthrust on balloon = weight of balloon and helium + $F_s$cos30

$$\rho_{air} V_{balloon}\, g = \rho_{helium} V_{balloon}\, g + m_{balloon}\, g + ke \cos 30$$

$$(1.29)(4.50)g = (0.180)(4.5)g + \left(\frac{15}{1000}\right)g + (80)e\, cos30$$

$$56.94705 = 7.9461 + 0.14715 + 69.282e$$

$$e = 0.705\text{m}$$

8 **Answer: A**

net work done on the gas

= -ve of area enclosed (as more work is doby BY gas when it expands from Y to X)

= $(0.5 \times 10^5)(1.0 \times 10^{-3})$ = - 50 J

9 **Answer: C**

Work done to stretch it 5.0 cm: $\frac{1}{2} k (0.05)^2 = 5$ K = 4000 N/m

Work done to stretch by further 5 cm, i.e. x = 10 cm :

$\frac{1}{2}(4000)(0.10)^2 = 20$ J Additional work required = 20 – 5 = 15 J

10 **Answer: B**

Velocity = Radius x Angular velocity

$v = r\,\omega$

Keeping ωconstant, *v proportional* r

Since the radius r of the roll increases at a steady rate,v proportional to *t*

11 **Answer: A**

$\phi = -\frac{GM}{r}$

$r\_A = -\frac{GM}{\phi\_A}$ and $r\_B = -\frac{GM}{\phi\_B}$

BA= r_B – r_A

$= -GM\left(\frac{1}{\phi_B} - \frac{1}{\phi_A}\right)$

= 0.89×10^6 m

$r\_C = -\frac{GM}{\phi\_C}$ and $r\_B = -\frac{GM}{\phi\_B}$

CB= r_C – r_B

$= -GM\left(\frac{1}{\phi_C} - \frac{1}{\phi_B}\right)$

= 1.11×10^6 m

12 Answer: C

C is incorrect because to keep moving in a straight line in path C, the spacecraft needs additional force with a radial component to act against pull of Earth's gravity.

This force needs to be adjusted in a way so as to be always equal and opposite to Earth's pull, such that it counteracts the radial acceleration.

Path B would not need any force from rocket if the gravitational force acting on spacecraft is just sufficient to provide the centripetal force to maintain the circular motion.

Paths A and D are paths of free fall when rockets are switched off; D on the way up, A on the way down.

13 Answer: B

Absolute zero = 0 K or - 273.15 °C

It is the temperature at which no more heat can be removed from a system.

Also It is the temperature at which the particles in a substance becomes motionless.

It is the *theoretical* temperature limitand has not been achieved as yet.

14 Answer: A

Mean K.E. of molecules depends on the absolutetemperature.

15 Answer: D

An oscillating system will have the same frequency as that of the periodic force applied to it. Thus the system will have a frequency of 2.50 Hz after being subjected to the force, and period
$T = 1/2.5 = 0.40$ s

So 0.15 s = 0.375 T

$v = 1.5\,(2\pi/0.4)\cos(2\pi/T\,(0.375T))$

$= 16.7$ cm s^{-1}

As t = 0.15 s is less than half a period, the mass would still be moving upwards.

16 Ans: D

$I \propto 1/x^2$

$I_Q/I_P = (1/2)^2 = ¼$

$I_Q/I_P = (A_Q/A_P)^2 = (6/A_P^2) = 1/4$

$A_P = 12.0$ µm

17 Ans: A

Zero intensity => node detected

At distance 0.34 m => 2nd Harmonics Standing Waves for a Node to fit ,
=> 0.34 m = ¼ wavelength, Wavelength = 1.36 m
Initial freq f = 340/1.36 = 250 Hz

The next higher frequency to have a Node at 0.34 m is when
0.34 m = ¾ wavelength , Wavelength' = 4/3 (0.34) = 0.45333 m
New freq f' = 340/0.45333 = 750 Hz

18 Ans: C

blue light from the sand has smaller Wavelength.

By $\theta \approx \lambda / b$, and by small angle approximation,

Range proportional to b/λ, so smaller wavelength, larger Range

19 ANS: D

$E = Q / 4\pi\varepsilon_0 r^2$

Distance from midpoint to each charge is0.50 m

Electric field strength due to one point charge,

$E = Q / 4\pi\varepsilon_0 r^2 = (2.0\times10^{-6}) / 4\pi(8.85\times10^{-12})(0.50)^2$

$E = 7.19\times10^4\,Vm^{-1}$

Electric field due to both charges is double thevalue above because the charges are unlike.$E = 1.4\times10^5\,Vm^{-1}$

20 ANS: D

field strength of the electric field at a point is numerically equal to the potential gradient at that point

so integral (area) of E-r graph gives the electric potential

21 ANS: B

When the current is in the positive direction,the diode allows it to flow through the

NTC thermister. The upper portion of thegraph is slightly decreasing in gradient due

to the properties ofthe thermistor.

When the current flows in the oppositedirection, the diode prevents it frompassing through the bulb. It flows throughthe other branch of the parallel connectioninstead. A resistor obeys Ohm's law socurrent varies proportionally to the voltage.

22 Answer: C

<u>When R_{rheo} increases</u>
In the circuit with resistor R,
p.d. V across R_{rheo} increases,
brightness of L1 increases (V^2/R_{L1}).
In the circuit with resistor R_{LDR},
p.d. V across R_{rheo} increases,
brightness of L2 increases and more light shines onto LDR
which decreases R_{LDR}, causing V_{rheo} to increase further,
which causes L2 to shine brighter.
Thus L2 is brighter than L1.

<u>When R_{rheo} decreases</u>
In the circuit with resistor R,
p.d. V across R_{rheo} decreases,
brightness of L1 decreases (V^2/R_{L1}).
In the circuit with resistor R_{LDR},
p.d. V across R_{rheo}decreases,
brightness of L2 decreases and less light shines onto LDR
which increases R_{LDR}, causing V_{rheo} to decrease further,
which causes L2 to shine less brightly.
Thus L1 is brighter than L2.

23 ANS: A

Use Fleming's Left Hand Rule, to derive the direction of the force, which is perpendicular to the magnetic field and current.

24 ANS: C

Selected velocity v = E/B

So for *v* to decreases, *B* shouldincreases.

25 ANS : D

Horizontal velocity component is constant

And so rate of change of flux linkage is constant

26 ANS: A

$2\pi f = 314$

f = 50 Hz

$\langle P \rangle = \frac{1}{2} V_p^2/R = 50$ W

27 Ans: B

B has the lowest wavelength/ highest frequency as it has the largest stopping potential. Stopping potential is a measure of the maximum KE of the photoelectrons which is dependent on the frequency of the radiation.

28 ANS: D

$\Delta x \Delta p \geq h \quad , \ \Delta p = m\Delta v$

$$\therefore \Delta v = \frac{h}{\Delta x . m} = 6.63\times10^{-34}\left(\frac{1}{43\times10^{-9}\times9.1\times10^{-31}}\right)$$

$\Delta v = 1.7\times10^{4}\ m s^{-1}$

29 ANS: D

The inference from most α- particles passed through the foil undeflected is that the diameter of the nucleus is much less than the diameter of the atom.

30 ANS: B

A – micro wave is non-ionising radiation

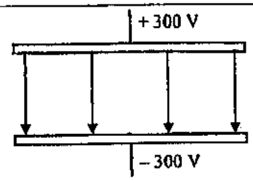
C –particle bombardment is also ionising radiation

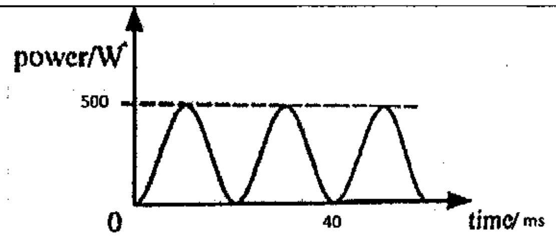
D – radiaitonsickeness can be caused by sources whether natural or man-made.

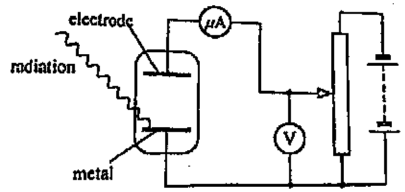
2019 Prelim H2 Physics
Paper 2 Solution

1(a)	Area = 280 x 230 = 64400 mm^2 $\frac{\Delta A}{A} = \frac{\Delta L}{L} + \frac{\Delta W}{W}$ $\frac{\Delta A}{A} = \frac{1}{280} + \frac{2}{100}$ = 0.0236 ΔA = 0.0236 X 64400 = 2000 mm^2 A = 64000±2000 mm^2	M1 M1 A1
1(b)	Accuracy refers to the closeness between the measured value 6.4 x 10^4 and the accepted or true value 8.00 x 10^4. ***As percentage difference of*** $\frac{80000-64400}{80000}$ ***x 100%=19.5% is big,*** the measurement is not accurate. ****Will not penalize students if percentage difference is not calculated.*** Precision refers to the degree of scattering among repeated measurements. **As the maximum percentage uncertainty of** $\frac{2000}{64000}$ **x 100%=3.1% is small,** *the measurement is precise.* ****Will not penalize students if percentage difference is not calculated.***	B1 B1
2(a)(i)	Work is done when a force moves its point of application in the direction of the force.	B1
2(a)(ii)	The mass m is moved without acceleration up a height h, and magnitude of the F = mg Since E_p = work done by Force F = force x distance moved cos θ = mg x h cos 0° = mgh	M1 M1 M1
2(b)(i)	Power = 60 x 55 x 9.81 x 32 / 60 = 17300 W	M1 A1
2(b)(ii)1.	Power = 1.5 x 10^4 x 32 / (60 sin 45°) = 11300 W	M1 A1
2(b)(ii)2.	Power input = (17300 + 11300) x (100/70) = 40900 W	M1 A1

3(a)(i)	The first law of thermodynamics states that the increase in the internal energy ΔU of a system is equal to the sum of the heat Q supplied to the system and work done W on the system. The latent heat of vaporisation is considerably higher because evaporation involve a considerably greater molecular separation and volume increase than melting. Hence, it involves a considerably greater increase in potential energy, and considerably more work has to be done by the system.	B1 B1 B1 B1
3(a)(ii)	Mass of the ethanol = 0.79 x 2 = 1.58 g Energy required from 30 °C to 78 °C = 2.4 x1.58 x (78 – 30) = 182 J Energy required for boiling= 840 x 1.58 = 1327 J Required thermal energy = 1327 + 182 = 1509 J	C1 C1 C1 A1
3(b)(i)	$\frac{P1V1}{T1} = \frac{P2V2}{T2}$ $\frac{2.6x10^6x2.9x10^{-5}}{790} = \frac{P2x2.9x10^{-4}}{314}$ Pressure of the gas = 103000 Pa	M1 A1
3(b)(ii)	ΔU = Q + W = 0 + -91 = -91 J Change in internal energy = -91 J	A1
3(b)(iii)	Internal energy of a system is the sum of kinetic energies and potential energies associated with the gas molecules. As the gas behaves ideally, internal energy is just the sum of kinetic energies of the gas molecules and it is proportional to the temperature of the gas system. A decrease in the internal energy of the gas that behaved ideally indicates a decrease in the average kinetic energy of the molecules, which would be reflected as a drop in temperature.	B1 B1

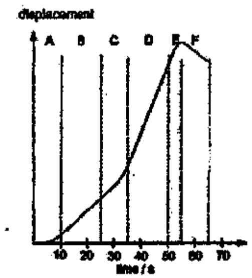
4(a)	Electric field strength is the electric force per unit positive charge at a point, due to an electric field. SI unit is N C^{-1}.	B1 A1
4(b)(i)		A1
4(b)(ii)	Electric field strength = 600 /0.012 = 50000 N C^{-1}	A1
4(b)(iii)	Work done = 600 x 1.6 x 10^{-19} = 9.6 x 10^{-17} J	A1
4(b)(iv)	gain in kinetic energy = 9.6 x 10^{-17} J	A1
4(c)	Electric force provides the centripetal force $e^2 / (4 \pi\varepsilon_o r^2) = m_e r \omega^2$ $\omega^2 = (1.6 \times 10^{-19})^2 / [(4 \pi\varepsilon_o)(9.11 \times 10^{-31})(5.3 \times 10^{-11})^3]$ $\omega = 4.12 \times 10^{16}$ rad s^{-1} Since $T = 2\pi/\omega = 1.53 \times 10^{-16}$ s $I = Q/t = 1.6 \times 10^{-19} / (1.53 \times 10^{-16})$ $= 1.05 \times 10^{-3}$ A	M1 A1 M1 A1

5(a)(i)	The root-mean-square value of an alternating current is the equivalent value of a steady direct current that will dissipate heat at the same average rate as the alternating current, in a given resistor.	B1 B1
5(a)(ii)	Frequency = 1 / (40 x 10^{-3}) = 25 Hz	A1
5(a)(iii)	Peak value = 10 A	A1
5(a)(iv)	Root-mean-square value of current = 10 / √(2) = 7.07 A	A1
5(a)(v)	 Both axes are labelled sufficiently Shape of graph is correct	 A1 A1
5(b)(i)	An ideal transformer is a device that steps up or steps down the voltage of an alternating supply without power loss.	B1
5(b)(ii)	Np/Ns = Is/Ip 300/6000 = Is/10 Is = 0.5 A	M1 A1

6(a)	 Photoelectric effect refers to the phenomenon that when some metal surfaces are illuminated by light, electrons are emitted. When the metal surface is illuminated with light even at a very low intensity, the flow of current in the ammeter indicates that photoelectrons are emitted almost instantaneously, as long as light is above a threshold frequency. This led to the idea that light exists as particle-like photons, each having a quantum of energy which can be absorbed by a an electron in the metal surface, releasing the electron to move towards the electrode.	B1 B1 B1 B1
6(b)(i)	The energy of a photoelectron can be increase by using radiation with higher frequency. This is because each electron only absorbs energy from one photon.	B1
6(b)(ii)	The rate of production of photoelectrons can be increased by increasing the intensity of the radiation. This is because it is proportional to the rate of photons arriving at the metal which is in turn proportional to the intensity of the radiation.	B1 B1
6(c)	The diffraction of light demonstrates the wave nature of electromagnetic radiation, which is inconsistent with the evidence shown by the photoelectric effect. Diffraction is the bending and spreading of waves when it passes through an aperture, giving raise to a wider image on the screen than the aperture. Only waves have this property. Particles would only travel in a straight line, thus resulting in an image the same size as the aperture. OR ANY OTHER EXPERIMENTS THAT PROVE WAVE NATURE OF LIGHT.	B1 B1 B1

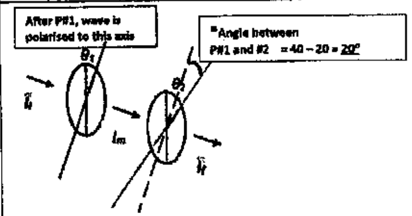
7(a)(i)	As diameter of the wire d increases, resistance of the wire R decreases.	B1
7(a)(ii)	Taking natural logarithm of $R = kd^n$, lg R = n lg d + lg k. $R = kd^n$ is valid because the graph lg R against lg d is a straight line.	B1 B1
7(b)(i)	Plotting the point for d = 0.46 mm correctly.	M1
7(b)(ii)	Drawing the best fit line correctly.	M1
7(b)(iii)	n = (0.34 – 1.2) / (-0.1 + 0.53) = -2.0	M1 A1
7(c)	lg (0.73) = -0.137. At lg d = -0.137, lg R = 0.41. $R = 10^{0.41}$ = 2.57 mΩ $= 2.57 \times 10^{-3}\Omega$	M1 M1 A1
7(d)	Y = m X + c (1.14) = -2.0 (-0.5) + c c = 0.14 $k = 10^{0.14} = 1.38 m\Omega\ mm^2$ k = 4ρL / π 1.38 = 4ρ(1000) / π ρ = 0.00108mΩ mm (no mark for unit)	M1 M1 M1 A1
7(e)(i)	Consider boiler: Using $P = I^2R$ $5.4 \times 10^6 = I^2 (6 \times 10^3)$ I = 30 A From graph, when I = 30 A, d = 0.42 mm Since minimum diameter required is 0.42mm. therefore use wire **gauge 8**	M1 M1 A1
7(e)(ii)	Lower manufacturing cost	B1
7(e)(iii)	For the same resistivity, thicker wires have lower resistance and as a results, there is lower power losses in them.	B1 B1
7(e)(iv)	Using V = IR $= 30 (6.6 \times 10^{-3})$ = 0.198 V	M1 A1

2019 Prelim Exams Paper 3 Answers

1	(a)	(i)	In Section E, the object undergoes a <u>constant deceleration of 7 m s^{-2}</u> until velocity becomes zero at t = 55 s, after which the particle <u>reverses its direction</u> as the velocity changes from positive to negative. In Section F, the particle travels at a <u>constant velocity of 5 m s^{-1}</u> in the direction <u>towards the starting point</u>.	B1 B1
		(ii)	 Sections B, D and F - Linear graphs Sections A and C – increasing distance at increasing rate Section E – increasing distance at decreasing rate, then decreasing distance (allow ecf from 1(a)(i) for Section E)	B1 B1 B1
	(b)	(i)	Consider the projectile motion from B to C: $S_y = u_{By}t + ½ at^2$ $1 = u_{By}t + ½ (9.81) t^2$ $1 = u_B \sin 30° t + ½ (9.81) t^2$ —Eqn (1) $S_x = u_{Bx}t$ $1 = u_B \cos 30° t$ Rearranging, $t = \frac{1}{\cos 30 u_B}$ Substitute into equation (1) $1 = u_B (0.5)\frac{1}{\cos 30 u_B} + ½ (9.81) (\frac{1}{\cos 30 u_B})^2$ $1 = 0.57735 + \frac{6.5399}{U_B^2}$ Solving, $U_B = 3.9$ m s^{-1}	M1 M2 M3
		(ii)	Lost in GPE = gain in KE mgh = ½ m $(U_B)^2$ h = 0.775 m	M1 A1

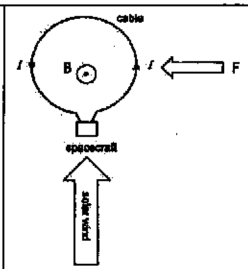
2	(a)		Since g α M/r, $\frac{g_M}{g_E} = (\frac{M_M}{M_E})(\frac{r_E}{r_M})^2$ = (1/81)(3.7)² = 0.169 Therefore, g due to Moon = 0.169 X 9.81 = 1.66 N kg⁻¹	M1 C1 A1
	(b)		$\frac{GM_E}{r^2} = \frac{GM_M}{(3.84\times10^8-r)^2}$ $81 = \frac{r^2}{(3.84\times10^8-r)^2}$ r = 3.46 x 10⁸ m	M1 A1
	(c)	(i)	ω = 2π/T = 2π/(27.3 x 24 x 60 x 60) = 2.66 x 10⁻⁶ rad s⁻¹ [1]	A1
		(ii)	Gravitational acceleration provides centripetal acceleration. GM/r² = rω² M = r³ω²/G = (3.84 x 10⁸)³ x (2.66 x 10⁻⁶)² / 6.67 x 10⁻¹¹ = 6.0 x 10²⁴kg	 M1 A1
		(iii)	Mass of Moon = 1/81 Mass of Earth F = GM_EM_M/r^2 = [6.67 x 10⁻¹¹ (6.0 x 10²⁴)² / 81] / (3.84 x 10⁸)² [1] = 2.01 x 10²⁰N	 M1 A1
		(iv)	The acceleration the moon causes on the Earth is very small as the Earth has a large mass. a = F/m = 2.01 x 10²⁰ / 6.0 x 10²⁴ = 3.35 x 10⁻⁵m s⁻²	B1 A1

2

3	(a)	(i)	Un-polarised light consists of light waves, which are transverse waves, with different planes of oscillation. Polarisation is the phenomenon in which the vibrations giving rise to waves are restricted in a direction of vibration, perpendicular to the direction of wave propagation.	B1 B1
		(ii)	Constructive interference occurs when the superposition of two waves produce a resultant wave of greater amplitude.	B1 B1
	(b)		 After Polariser 1 (#1): $I_m = I_i cos^2 20$ After Polariser 2 (#2): $I_f = I_m cos^2 20$ = $(I_i cos^2 20)(cos^2 20)$ = 0.780 I_i	 C1 A1
	(c)	(i)	sin θ = λ/b $sin\theta = \frac{0.003}{2.4} = \frac{\lambda}{b}$ $b = 5.04 \times 10^{-4}\ m$ = 0.504 mm Allow range of x from 0.003 to 0.0035 m	C1 A1
		(ii)	b↓, sinθ↑, θ↑ increase in width of central maximum, effect: (either) maxima are farther, (or) therefore the bright fringes have lower intensity (to get the second mark)	B1 B1

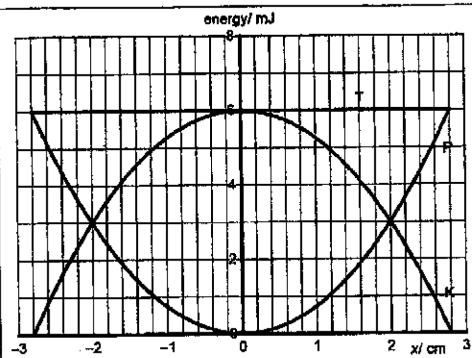
3

4	(a)	(i)	$R = \frac{\rho l}{A} = \frac{1.1\times10^{-6}\times98}{\pi(\frac{1.1\times10^{-3}}{2})^2}$ = 113 Ω		A1
		(ii)	As the wire stretches, its length increases and it cross sectional area decreases. From $R = \frac{\rho l}{A}$, R will increase.		B1
	(b)	(i)	$R_{PQ} = 1\% \times 113 = 1.13\Omega$ $V_{PQ} = \frac{R_{PQ}}{R_{PQ} + R + r} \times E_1$ $V_{PQ} = \frac{1.13}{1.13+R+r} \times E_1$ V_{PQ} per unit length $= \frac{\frac{1.13}{1.13+R+r}\times E_1}{0.98}$ $= \frac{1.15}{1.13+R+r} \times E_1$		M1 C1 for correct R and length of PQ A1
			1.	Length PJ = 1/3 x 0.98 = 0.327 m Using (b)(i) ans, $V_{PJ} = 0.327\times\frac{1.15}{1.13+R+r}\times E_1$ $= 0.327\times\frac{1.15}{1.13+1.0+r}\times 12$ At balanced length, $V_{PJ} = E_2$ $0.327\times\frac{1.15}{1.13+1.0+r}\times 12 = 1.5$ r = 0.878 Ω	C1 C1 A1
			2.	If the resistance R is too high, the pd across the PQ will be too low. If the p.d. across PQ is lower than the e.m.f. of E_2, there will be no balance point.	B1 B1

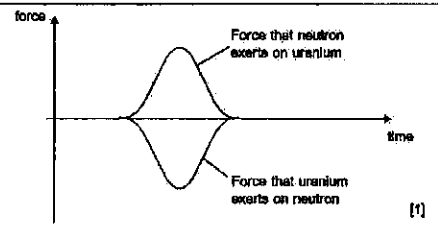
5	(a)		The current in the magsail sets up a magnetic field (which is out of the page). A charge moving in a magnetic field experiences a force, thus getting deflected. By Newton's third law, there is an equal and opposite force by the deflected charges on the magsail, thus propelling it.	B1 B1
	(b)		Photons do not have charge.	B1
	(c)	(i)		
		(ii)	EK = ½ mv² $500 \times 10^3 \times 1.60 \times 10^{-19} = ½ (1.67 \times 10^{-27}) v^2$ $v = 9.79 \times 10^5$ m s⁻¹	C1 A1
		(iii)	$B = \frac{\mu_0 NI}{2r}$ $B = \frac{4\pi\times10^{-7}(1)3000}{2(64)}$ $= 29.5\,\mu T$	C1 A1
		(iv)	$F = Bqv = 29.5 \times 10^{-6} \times (1.6 \times 10^{-19}) \times (9.79 \times 10^5)$ $= 4.62 \times 10^{-17}$ N	C1 A1

6	(a)		$□ = NBA = 400□5□10^{□5}□\sin 60°□25□10^{□4}$ $= 4.33□10^{□5}$ Wb	C1 A1
	(b)	(i)	$□□ = □_f □□_i = [4.33□(□4.33)] \times 10^{□5} = 8.66 \times 10^{□5}$ Wb	A1
		(ii)	Induced emf $E = \left\|\frac{d□}{dt}\right\| = \frac{□□}{□t}$ $= \frac{8.66\times10^{-5}}{2.5}$ $= 3.46 \times 10^{-5}$ V	 C1 A1
	(c)		Clockwise direction from the top view.	A1
	(d)		According to Lenz's Law, the induced current flows in a direction so as to oppose the change that produces it. This will result in a magnetic force that opposes the rotation of the coil. Mechanical energy / kinetic energy is converted to electrical energy.	B1 B1

7	(a)		Net force acting on the body and the net torque acting on the body is zero .	B1 B1
	(b)		By considering moments about the left end of the rod: $0.25L \times 400 + 0.50L \times 120 = T_2\cos 30^0 \times L$ $T_2 = 185$ N horizontally: $185 \sin 30^0 = T_1 \sin 14.4^0$ $T_1 = 371$ N OR $T_2\cos 30^0 + T_1\cos 14.4^0 = 400 + 120$ $T_1 = 371$ N OR Considering moments about right end of rod: $0.75L \times 400 + 0.50L \times 120 = T_1\cos 14.4^0 \times L$ $T_1 = 372$ N	 C1 A1 C1 A1
	(c)		The frequency f of a body undergoing simple harmonic motion refers to the number of oscillation it undergoes per unit time and is measured in cycles per second. The angular frequency ω is the angular velocity of the body in SHM measured in radians per second and ω = 2πf.	B1 B1
	(d)	(i)	When the spring is displaced by x, one of the springs (left) is compressed and the other spring (right) is extended. Both springswill exert a force of -2kx on the mass. F = ma = -2kx $a = -\frac{2kx}{m}$	B1 B1

		(ii)	$E_T = \frac{1}{2}m\omega^2 x_0^2 = \frac{1}{2}\times 0.038 \times (2\pi\times 3.2)^2 \times 0.028^2$ $= 0.00602$ J $= 6.0$ mJ (2 sf)	M1 A1
		(iii)	When K.E. of ball is equal to P.E. of spring, $E_P = \frac{1}{2}E_T$ OR $E_P = E_K$ $\frac{1}{2}m\omega^2 x^2 = \frac{1}{2}E_T$ $\frac{1}{2}m\omega^2 x^2 = \frac{1}{2}m\omega^2 (x_o^2 - x^2)$ $x = \sqrt{\frac{E_T}{m\omega^2}}$ $x = \frac{x_0}{\sqrt{2}}$ $= \sqrt{\frac{0.00602}{0.038\times(2\pi\times 3.2)^2}}$ $= \frac{2.8}{\sqrt{2}}$ $= 0.0198$ m $= 2.0$ cm $= 1.98$ cm $= 2.0$ cm $= 0.020$ m Note: Distance can only be positive.	C1 C1 A1
		(iv)	 Fig. 2.2 T: Horizontal line at 6 mJ K: max curve between 0 to 6 mJ P: min curve between 0 to 6 mJ	 B1 B1 B1

			Deduct 1m for (max 3m): Any missing labels K & P not intersecting at 3 mJ (not marking for 2.0 cm) Any graphs not starting and ending at ± 2.8 cm.	
	(e)		In a vertical spring mass system, there is a change in gravitational potential energy. At the highest position, EPE will be reduced. or at the equilibrium position, the KE will be reduced.	B1 B1

8	(a)			The principle of conservation of momentum states that the total momentum of a system remains constant if no external resultant force acts on the system.	B1
	(b)	(i)			A1
		(ii)		For each curve, the area under the graph is change in momentum of each body. The graphs are mirror images of each other such that the gain in momentum of one is equal to the loss in momentum of the other, resulting in total momentum remaining constant.	B1 B1
	(c)	(i)	1.	Q = 1.2 MeV	A1
			2.	v = √(E/(½ m_e) = 6.5 x 10^8 ms^{-1}	A1
			3.	m(Po) = m(Bi) – m_e – Q/c^2 = [(209.939u) – (9.11 x 10^{-31}/1.66 x 10^{-27}) – (1.2x10^6x1.60x10^{-19}/c^2)]/(1.66 x 10^{-27} kg) = 209.937 u Allow ecf from (c)(i)1. for Q value	C1 C1 A1
		(ii)		Range of values accepted : 0.16 - 0.19 MeV	A1

		(iii)	For a stationary nucleus decaying into the beta particle and daughter nucleus, the conservation of linear momentum requires that $\underline{p_1} = -\underline{p_2}$. The sum of kinetic energies will thus be $(p_1)^2/2m_1 + (p_2)^2/2m_2$ = E, which ought to equal the energy released in the reaction, which, if equal to the increase in the total binding energy/decrease in total mass, ought to be constant. The range of beta particle energies and thus the supposed energy released E, seem to suggest that the energy released was not constant, in contradiction to the principle of conservation of energy.	B1 B1
		(iv)	The existence of another undetected particle known as neutrino.	B1
	(d)	(i)	The decay constant refers to the probability of decay of a radioactive nucleus in a time of one second.	B1
		(ii)	Using $A = A_o e^{-\lambda t}$, $A = 375e^{-\left(\frac{\ln 2}{8.04} \times 2.5 \times 7\right)}$ **A = 82.9 Bq**	C1 C1 A1
		(iii)	$A = \lambda N$ $A = \left(\frac{\ln 2}{t_{\frac{1}{2}}}\right)\left(\frac{M}{M_m} N_A\right)$ $M = \frac{(375)(8.04 x 24 x 60 x 60)\ (131 x 10^{-3})}{(\ln 2)(6.02 x 10^{23})}$ **≈8.2 x 10^{-17} kg**	C1 C1 A1

Q4

Diagram

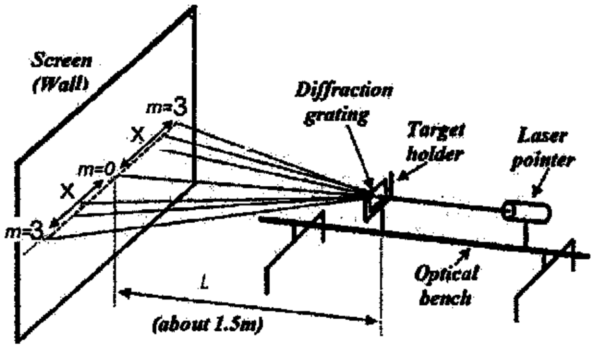


Diagram of workable procedure

(All Diagram marks not awarded if grating is not shown in between screen and laser pointer)	**Max 2**
Diagram showing grating in between screen and laser, with use of retort stand and clamps to hold them	D1
Diagram showing labelling of screen distance L and spot separation (x) for the 3rd spot	D2

Variables / Basic Procedures

IV #1 is frequency f of light source, to be varied using the different lasers provided IV #2 is number of lines on grating, N, to be varied by using different gratings DV is θ, to be measured using a protractor or by calculation methods (tan θ or Pythagoras on sin θ)	V1
Keeping one of the IV constant, vary the other one and measure for p. Then, keep the other IV constant now, and vary the first one to measure for θ Control Variables – keep Distance L between the screen and grating constant	V2

Procesures

Measure for length of L using measuring tape Measure for distance x between middle bright spot and 3rd bright spot using a ruler	M1
IV#1 - frequency f of light source Use one of the grating throughout this part of the experiment, to keep N constant Use different laser pointers with diff freq behind the grating Measure for distance middle bright spot and 3rd bright spot using a ruler Record values of f, L, x in Table A.	M2
IV#2 - number of lines on grating, N Use one of the laser throughout this part of the experiment, to keep f constant Use different gratings with diff N Measure for distance middle bright spot and 3rd bright spot using a ruler record values of N, L, x in Table B.	M3

Analysis (ALL details are required for the mark)

Calculate tanθ = x/Lin tables A and B (or, use Pythagoras) From Table A, Plot graph of lg(tanθ) versus lg(f). Gradient = b Y-Intercept = lg($3kN^a$)	A1
From Table B, Plot graph of log(sinθ) versus log(N). Gradient = a Y-Intercept = lg ($3kf^b$)	A2

Steps for Accuracy: max 2

Do preliminary Measurements to determine optimum screen distance L (> 1 m) for spot separation to be large enough (> a few cm)	SA1
Ensured measuring tape for L is straight , positioned along mid-point of grating and perpendicular to screen, fixed by being taped down to the table surface	SA2
Measure for 2x between 3rd bright spots on either side, to divide by 2, to reduce uncertainty in x	
Use of setsquare etc to ensure alignment of grating is perpendicular to screen	
Conduct in darkened room to see bright spots clearly	
Other credible details	

Safety considerations

Do not direct laser into eyes / always stand behind the laser beam	S1

Total: 12